FOREIGN COMPETITIVE THREATS

TO US HIGH TECHNOLOGY INDUSTRIES

CABINET COUNCIL ON COMMERCE AND TRADE

25 OCTOBER 1982

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A

THREATS

- US LOSING MARKET SHARE/COMPETITIVE EDGE

  - MICROELECTRONICS: JAPAN LEADS IN 64K RAMS (70 PERCENT SHARE)

  - TELECOMMUNICATIONS: JAPAN NOW LEADER IN FIBER OPTICS

  - COMPUTERS: JAPAN HAS PRICE PERFORMANCE EQUIVALENCE

  - CIVIL AIRCRAFT: AIRBUS CONSORTIUM NOW NUMBER TWO

  - PRODUCTION TECHNOLOGY: BY LATE 1980S FOREIGN MANUFACTURERS COULD BE SUPPLYING ABOUT HALF OF THE MACHINE TOOLS CONSUMED IN THE US

  - AUTOMOBILES: HEAVY FOREIGN R&D IS LEADING TO NEW GENERATIONS OF FUEL EFFICIENT QUALITY AUTOS WITH HIGH TECHNOLOGY

- LOSS OF COMPETITIVE EDGE HAS SIGNIFICANT STRATEGIC AND ECONOMIC IMPLICATIONS

  - UNDERMINE MILITARY CAPABILITIES
    - -- VULNERABLE TO CUTOFFS IN SUPPLY OF CERTAIN COMPONENTS

-- LIMITS MILITARY SYSTEMS CAPABILITY

- ERODES BALANCE OF TRADE IN MANUFACTURED PRODUCTS
  - -- PROJECTED LOSS OF $3 BILLION PER YEAR (1981-85) ON AVERAGE IN COMMERCIAL AIRCRAFT EXPORTS (TO AIRBUS)
  - -- SLOWED GROWTH IN BALANCE OF TRADE IN COMPUTERS COULD BE OVER $9 BILLION SURPLUS IN 1982
  - -- LARGE TRADE IMBALANCES IN CERTAIN SEMICONDUCTOR PRODUCTS (64K RAM)
- REDUCED DOMESTIC EMPLOYMENT
  - -- 25,000 JOBS DIRECTLY RELATED TO THE AEROSPACE INDUSTRY FOR EVERY $1 BILLION LOST IN CIVIL AIRCRAFT EXPORTS
  - -- FOR EVERY JOB LOST IN AEROSPACE, 2 ADDITIONAL JOBS ARE LOST IN RELATED INDUSTRIES
  - -- RECENT LAYOFFS IN THE SEMICONDUCTOR INDUSTRY CONTINUE
- WEAKENING OF THE OVERALL INDUSTRIAL BASE
  - -- DEPENDENCE ON FOREIGN SOURCES OF SUPPLY (MACHINE TOOLS, SEMICONDUCTORS AND AIRCRAFT SUB-SYSTEMS)

-- Loss of High Technology Linkage that Helps Other Industries

- Increased International Political Tensions
  -- Semiconductor Dumping, Nippon Telegraph and Telephone Procurement, "Voluntary" Quotas on Automobiles

- Complicates Technology Transfer Problems
  -- East-West: Alternate Sources of Supply Lead to Losses of "De Facto" Control

  -- West-West: Foreign Governments use Market Access to Extract US Technology.
     F-15 Coproduction Enhances Japanese Commercial Capability

- Loss of International Prestige

B

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RELATIONSHIP OF FOREIGN GOVERNMENTS TO THEIR INDUSTRIES

o GOVERNMENT SUPPORT

- R&D SUPPORT
  - -- SUBSIDIES
  - -- LOANS
  - -- LOAN GUARANTEES
  - -- GOVERNMENT R&D

EXAMPLES:

JAPANESE GOVERNMENT-INDUSTRY RESEARCH ASSOCIATIONS CHANNEL GOVERNMENT MONEY DIRECT TO INDUSTRY

JAPANESE "LOANS" FOR R&D ALMOST NEVER PAID BACK

EFFECTIVE GOVERNMENT FINANCIAL SUPPORT OFTEN EXCEEDS PUBLICLY STATED BUDGETS

- TAX POLICY
  - -- R&D CREDITS
  - -- ACCELERATED DEPRECIATION; SPECIAL FOR HIGH TECHNOLOGY TOOLING
  - -- SPECIAL TAX CREDITS FOR HIGH TECHNOLOGY PRODUCTS

EXAMPLES:

JAPANESE GOVERNMENT TAX SUPPORT FOR R&D MORE EXTENSIVE THAN OPENLY KNOWN -- TAX CREDITS PROVIDED FOR FOREIGN TECHNOLOGY ACQUISITION.

- RESTRUCTURING INDUSTRIES
  -- SELECTS TARGET INDUSTRIES (PICKS WINNERS)
  -- FOSTERS COOPERATIVE INDUSTRIAL R&D
  -- COORDINATES INVESTMENT, PRODUCTION AND EXPORT LEVELS
- EXPORT ASSISTANCE
  -- SUBSIDIZED FINANCING
  -- LINKAGES WITH BROADER POLITICAL GOALS
- OTHERS
  -- PROCUREMENT
  -- EDUCATION SUPPORT
  -- AID CAPITAL FORMATION

SEE HANDOUT ON EXAMPLES OF FOREIGN GOVERNMENT SUPPORT MECHANISMS (12 COPIES CLIPPED TO BACK COVER)

- GOVERNMENT PROTECTION
  - BARRIERS TO TRADE
    - -- TARIFFS
    - -- NON TARIFF (USE OF STANDARDS, LOCAL CONTENT LAWS)
- IMPACT ON COMPETITIVE STRENGTH OF FOREIGN INDUSTRIES
  - ALLOWS PRICING BELOW MARKET, THEREBY INCREASING MARKET SHARE
  - INCREASES R&D AND CAPITAL INVESTMENT AT LOW RISK
  - AIDS MARGINAL PRODUCERS, CREATING NEW COMPETITORS
  - ALLOWS FULLER PRODUCT LINES
  - PERMITS LONG-RANGE BUSINESS PLANS

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OTHER FACTORS AFFECTING COMPETITION

- o GENERAL ECONOMIC CLIMATE
- o COST OF CAPITAL
  - CAPITAL INTENSIVE NATURE OF HIGH TECHNOLOGY INDUSTRIES
  - FOREIGN FIRMS BENEFIT FROM LOWER EFFECTIVE CAPITAL COSTS
- o GLOBAL NATURE OF INDUSTRY AND OF FINANCIAL MARKETS
  - PRESSURES FOR INTERNATIONAL COLLABORATION
  - CURRENCY EXCHANGE PROBLEMS
- o TECHNOLOGY TRANSFER
  - DIFFICULT TO CONTROL DIFFUSION IN HIGH TECHNOLOGY AREAS
- o SHORTAGES OF SKILLED MANPOWER
  - JAPAN GRADUATES SAME NUMBER OF ELECTRICAL ENGINEERS WITH HALF THE US POPULATION

D

OPTIONS AVAILABLE

- o RECOGNITION OF HIGH TECHNOLOGY INDUSTRIES AS KEY TO FUTURE US ECONOMIC AND MILITARY SECURITY.
- o DEVELOP STRATEGIES TO COUNTER THE MOST EFFECTIVE FOREIGN GOVERNMENT SUPPORT MECHANISMS.
  - CHALLENGE FOREIGN CARTEL BEHAVIOR
  - ASSURE EQUAL MARKET ACCESS.
  - TAKE ACTION AGAINST ILLEGAL TECHNOLOGY ACQUISITION BY OUR COMPETITORS
  - PRESS FOR AN END TO CORRUPT BUSINESS PRACTICES BY FOREIGN FIRMS
  - CHALLENGE THE NATURE AND EXTENT OF FOREIGN GOVERNMENT SUBSIDIES
- o DEVELOP STRATEGIES TO ACCELERATE THE PACE OF US TECHNOLOGICAL PROGRESS.
  - CONSIDER EXPANDED GOVERNMENT FUNDING FOR R&D (SUCH AS DOD VHSIC PROGRAM).
  - ENCOURAGE JOINT DEVELOPMENT EFFORTS BY US INDUSTRY

E

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OPTIONAL

DESCRIPTION OF CIA EFFORTS

- AGENCY HAS ANTICIPATED COMPETITIVE PROBLEMS IN SELECTED INDUSTRIES
  - PREDICTED THE RISE OF AIRBUS INDUSTRIES
  - INCREASED AWARENESS OF FUTURE COMPETITIVE THREATS (COMPUTERS AND SEMICONDUCTORS)
- EXPANDING COLLECTION, RESEARCH AND ANALYSIS ON FOREIGN THREATS TO US INDUSTRIES
  - SEMICONDUCTORS
  - COMPUTERS
  - TELECOMMUNICATIONS
  - COMMERCIAL AIRCRAFT
  - MATERIALS
  - INDUSTRIAL AUTOMATION
- ASSESSING FOREIGN INDUSTRIAL STRATEGIES, TECHNOLOGICAL CAPABILITIES, GOVERNMENT SUPPORT FOR INDUSTRY, AND OTHER FACTORS AFFECTING COMPETITION

- Agency Collection and Analysis is Showing that Foreign Government Involvement is More Extensive and that the Competitive Threat may be More Serious than Commonly Believed.
- CIA is Working Closely with Other Departments and Agencies.

F

OPTIONAL

POSSIBLE RELEASE OF INTELLIGENCE INFORMATION TO US INDUSTRY

- SELECTED INTELLIGENCE INFORMATION MAY BE/COULD BE BENEFICIAL TO US INDUSTRY (SEE ATTACHED MEMO FOR EXAMPLE)
- RECOMMENDS CCCT DISCUSSION OF THIS POSSIBILITY

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THE WHITE HOUSE
WASHINGTON

CABINET AFFAIRS STAFFING MEMORANDUM

DATE: 10-20-82 NUMBER: 077550CA DUE BY: ______

SUBJECT: Cabinet Council on Commerce and Trade - Monday, October 25, 1982 2:00 p.m. in the Cabinet Room (with the President)

	ACTION	FYI
ALL CABINET MEMBERS	☐	☐
Vice President	☑	☐
State	☑	☐
Treasury	☑	☐
Defense	☑	☐
Attorney General	☑	☐
Interior	☐	☑
Agriculture	☑	☐
Commerce	☑	☐
Labor	☑	☐
HHS	☐	☑
HUD	☐	☑
Transportation	☑	☐
Energy	☑	☐
Education	☐	☑
Counsellor	☑	☐
OMB	☐	☑
CIA	☐	☑
UN	☐	☑
USTR	☑	☐
CEA	☑	☐
CEQ	☐	☐
OSTP	☐	☐
	☐	☐
	☐	☐

	ACTION	FYI
Baker	☑	☐
Deaver	☐	☐
Clark	☑	☐
Darman *(For WH Staffing)*	☑	☐
Harper	☑	☐
Jenkins	☐	☑
Wheeler	☐	☑
Kudlow	☐	☑
	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐
CCCT/Gunn	☑	☐
CCEA/Porter	☐	☐
CCFA/Boggs	☐	☐
CCHR/Carleson	☐	☐
CCLP/Uhlmann	☐	☐
CCMA/Bledsoe	☐	☐
CCNRE/Boggs	☐	☐

REMARKS: The President will chair a meeting of the Cabinet Council on Commerce and Trade, Monday, October 25, at 2:00 p.m. The agenda and background papers are enclosed.

'82 OCT 22 11 16 AM

ER

RETURN TO: ☐ Craig L. Fuller, Assistant to the President for Cabinet Affairs ☑ Becky Norton Dunlop, Director, Office of Cabinet Affairs

THE WHITE HOUSE

WASHINGTON

October 21, 1982

MEMORANDUM FOR MEMBERS OF THE CABINET COUNCIL ON COMMERCE AND TRADE

FROM: WENDELL GUNN
Executive Secretary

SUBJECT: Agenda for Meeting of October 25, 1982
2:00 p.m., Cabinet Room

Attached is the Working Group's report on U.S. Competitiveness in High Technology, to be discussed at Monday's Cabinet Council meeting with the President.

THE WHITE HOUSE

WASHINGTON

CABINET COUNCIL ON COMMERCE AND TRADE

October 25, 1982

2:00 p.m.

Cabinet Room

AGENDA

1. High Technology/CM#129
2. Presidential Statement on Minority Business/CM#170

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

MEMORANDUM FOR THE PRESIDENT

FROM: Malcolm Baldrige, Chairman MB
Pro Tempore Cabinet Council
on Commerce and Trade

SUBJECT: Competitive Position of U.S. High
Technology Industries

In December of 1981, the Cabinet Council on Commerce and Trade (CCCT) directed that a study be performed on the current competitive posture of the United States in high technology.

The concerns of the CCCT with U.S. performance in high technology sprang from the recognition that although the United States is now the world leader in many areas of advanced technology, its preeminence has been challenged and is seriously threatened.

The United States occupies a unique leadership position in the world's political and economic structure--a leadership role underwritten by its preeminence in advanced technology. The possible erosion of this preeminence could have far-reaching economic, political, and national security consequences for the entire free world.

The special combination of contributions to the U.S. economy of high-technology industries--including high productivity growth and low price growth--indicate the importance of this segment to the overall strength of the U.S. industrial base. There is a direct linkage between the research activities conducted by high-technology industries and the U.S. standard of living. Research nutures innovation, which feeds technological progress, which leads to productivity gains and new jobs.

As the high-technology industries of other countries have emerged as strong international competitors, U.S. high-technology industries are facing a significantly altered competitive environment. In the new environment, the United States faces a major challenge.

Key findings of the CCCT study on high technology competitiveness include:

- o High technology industries are vital to the U.S. economy. Their growth rate has been twice that of total industrial output, and they contribute the bulk of technological advances to all sectors of the economy.

- o National security depends upon the technology-intensive industries both for sophisticated items essential to modern weapons superiority, and for a strong and flexible industrial capability for future contingencies.

- o The United States will have to depend heavily on its areas of greatest strength -- principally advanced technology and agriculture -- to meet increased competition in world markets. The technological challenge confronting the United States can benefit all competitors and nations through increased efficiency and growth.

- o There has been a decline in the international market position of U.S. high technology industries from a position of dominance to one of being strongly challenged. Foreign competition in high technology has increased dramatically, with developments in selected new areas indicating that technological advantages have shifted overseas.

- o The major technological challenge to the United States is from Japan. Now limited to a few high technology sectors, this challenge is rapidly expanding.

- o An array of factors influence U.S. versus foreign advances in technology. The most important of these are:
  - the overall state of the domestic economy,
  - cost and supply of capital,
  - relative R&D efforts,
  - the transfer of technology,
  - availability of scientists and engineers, and
  - explicit industrial policies toward technology-intensive sectors.

- o If present trends continue, some or all of these factors could contribute to a further decline in the competitive position of U.S. high technology industries.

- Foreign government industrial programs to promote high technology industries have adversely affected U.S. high technology industries and will, if trends continue, place U.S. business at a disadvantage, even with an ideal environment for high technology within the United States. Industry targeting by foreign governments against specific high technology areas could preclude valuable long term U.S. technological developments.

The evidence in the CCCT Study justifies your concern for our continued preeminence in high technology. We have been developing a work program within the CCCT to assess the factors which have influenced our competitiveness in high technology and identify the necessary policy responses. I believe this should be a critical element in this Administration's effort to improve our economic performance and warrants our sustained attention.

REVISED DRAFT

AN ASSESSMENT OF U.S. COMPETITIVENESS IN HIGH TECHNOLOGY INDUSTRIES

Ocotober, 1982

Executive Summary

In December of 1981, the Cabinet Council on Commerce and Trade (CCCT) directed that a study be performed on the current competitive posture of the United States in high technology. This study is submitted in fulfillment of that request.

The concerns of the CCCT with U.S. performance in high technology sprang from the recognition that the gains to the United States from advanced technology are quite significant.

The United States occupies a unique leadership position in the world political and economic structure--a leadership role underwritten by its preeminence in advanced technology. The possible erosion of this preeminence could have far-reaching economic, political, and national security consequences for the United States.

The special combination of contributions to the U.S. economy of high-technology industries--including high productivity growth and low price growth--indicate the importance of this segment to the overall strength of the U.S. industrial base. There is a direct linkage between the research activities conducted by high-technology industries and the U.S. standard of living. Research nutures innovation, which feeds technological progress, which leads to productivity gains. Productivity over the long run is the predominate element which determines the overall ability of the U.S. economy to grow and in turn to produce a higher standard of living and new jobs.

As the high-technology industries of other countries have emerged as strong international competitors, U.S. high-technology industries are facing a significantly altered competitive environment. In the new environment, the United States faces a major challenge to maintain its broad technological preeminence.

This report summarizes an interagency examination of U.S. high technology industries -- their importance, their trade performance, and the factors influencing their competitiveness vis-a-vis foreign competitors. Key findings include the following:

- High technology industries are vital to the U.S. economy. Their growth rate has been twice that of total industrial output, and they contribute the bulk of technological advances to all sectors of the economy.

- National security depends upon the technology-intensive industries both for sophisticated items essential to modern weapons superiority, and for a strong and flexible industrial capability for future contingencies.

- The United States will have to depend heavily on its areas of greatest strength -- principally advanced technology and agriculture -- to meet increased competition in world markets. The technological challenge confronting the United States can benefit all competitors and nations through increased efficiency and growth.

- Over the last twelve years, there has been a decline in the international market position of U.S. high technology industries from a position of dominance to one of being strongly challenged. Market share for the high technology group -- and for nearly all individual industries -- has fallen. Foreign competition in high technology has increased dramatically, with developments in selected new areas indicating that technological advantages have shifted overseas.

- An array of factors influence U.S. versus foreign advances in technology. The most important of these across all industries are:
  - the overall state of the domestic economy,
  - cost and supply of capital,
  - relative R&D efforts,
  - the transfer of technology,
  - availability of scientists and technicians, and
  - explicit industrial policies toward technology-intensive sectors.

- If present trends continue, some or all of these factors could contribute to a further decline in the competitive position of U.S. high technology industries.

- A free market system encourages technological advances, but significant impediments to free and open markets exist world-wide. For example, foreign governments use closed markets, direct fiscal support, and guidance to capital markets to create an artificial advantage for favored high technology sectors. Recognition of these impediments and reasoned efforts to counter them are essential to prevent serious disadvantages for U.S. firms.

- Foreign government industrial programs to promote high technology industries have adversely affected U.S. high technology industries and will, if trends continue, place U.S. business at a disadvantage, even with an ideal environment for high technology within the United States. Industry targeting by foreign governments against specific high technology areas could preclude valuable long term U.S. technological developments.

- The major technological challenge to the United States is from Japan. Now limited to a few high technology sectors, this challenge is expected to broaden in the future.

We believe that the evidence justifies concern for our continued preeminence in high technology. While it was inevitable that the abnormal postwar gap in technology between the United States and other advanced countries would narrow, we must appreciate that that era has past. We must begin a process to identify the appropriate policy responses. The Cabinet Council on Commerce and Trade is undertaking to assess both industry specific and broader factors which have influenced United States competitiveness in high technology.

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I. INTRODUCTION

The gains to the United States from advanced technology are quite significant. The standard of living, national security, and the variety of free choices available in this country in large measure are a result of the advanced skills and knowledge we have developed and applied. The recognition of technology's importance to the United States -- and the recognition that leadership in technology is a perishable asset which can be lost if not vigorously maintained -- have led to this assessment of the current U.S. position.

Purpose

This report summarizes an interagency examination of the importance of advanced technology to the United States, the performance of this country's technology-intensive industries, and the factors influencing relative technological advantage between the United States and its major foreign competitors. The purpose of this effort is to provide the foundation for a subsequent study where policies related to U.S. technological strength will be considered.

The interagency effort, and this report, have prescribed limitations in scope. The intent has been to perform a synthesis of existing understanding and research pertinent to the study's objectives. A significant original research program has not been attempted...

Organization of the Report

This report is presented in four major sections. Section II describes the nature of the most technology-intensive industries and the reasons for our examination of this specific group in detail.

In Section III the role of high technology industries in U.S. international trade is discussed. The relative performance of these industries is assessed in relation to overall U.S. trade performance.

The factors which we have judged to be the major elements affecting technology are presented in Section IV. Included in this section are descriptions of foreign actions which directly affect U.S. high technology industries.

Section V outlines implications for further work.

Supporting appendices are located at Tabs A through D.

II. THE IMPORTANCE OF HIGH TECHNOLOGY INDUSTRIES

High technology industries* are identified by the simultaneous presence of two characteristics: (1) an above average level of scientific and engineering skills and capabilities, compared to other industries (alternatively R&D effort relative to sales can be used); and (2) a rapid rate of technological development.

High technology is differented from "high science" or pure science in that it is technology developed for commercial application. Pure science is concerned with the state of knowledge independent from any relationship it may bear to commercial applications. The continued dominance of the U.S. in high science as illustrated by its "monopoly" on Nobel prizes and numbers of scientific articles in leading journals is not at issue. In fact, some would confuse the strength in high science with strength in high technology. There are linkages but they are complex. Countries can be highly competitive in a high technology industry yet make few, if any, contributions to the underlying scientific base.

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*This report examines the performance of industries that are technology intensive. In order to examine world trade peformance, a specific set of industries must be identified as "high technology industries". Available trade data categories define industries at a fairly aggregated level. Consequently, some specific sub-categories that have relatively low technology intensity are included in the definition. Also, some specific high technology industries are excluded for the same reason. Detailed industry examinations -- such as those discussed at the end of this section -- should, though, consider specific high technology industries (for instance, robotics and computer-related machine tools) which are excluded from the aggregate definition made for trade data purposes.

It should be recognized that by its very definition high technology industries are a dynamic collection. Any definition of a high technology industry must involve an industry analysis at a particular point in time. Thus the collection of industries identified as high technology can change over time. However as detailed in Appendix A, the conclusions developed from the broad data are not sensitive to the definition selected for high technology.

For further discussion of high technology industry definitions, see Appendix A.

The industries comprising the high technology sector of the economy for examination of trade data have been identified based on their R&D expenditures to include:

- o Aircraft and parts;
- o Computers and office equipmment;
- o Electrical equipment and components;
- o Optical and medical instruments;
- o Drugs and medicines;
- o Plastic and synthetic materials;
- o Engines and turbines;
- o Agricultural chemicals;
- o Professional and scientific instruments; and
- o Industrial chemicals.

Economic Importance

The most technology-intensive U.S. industries provide a significant contribution to overall output growth, productivity increases, and trade performance. Key aspects of the role played by high technology industries in our economy include the following:

- o During the past decade high technology industries as a group had a rate of growth of real output which was more than twice that of total U.S. industrial real output. (See Figure 2.1) Nine out of the ten fastest growing U.S. industries in recent years have been high technology industries.
- o The rate of increase in prices of high technology industry products during the 1970-1980 period was only one-third that of the country's overall inflation rate. (See Figure 2.2)
- o High technology product trade has contributed large surpluses to our balance of trade. (See Figure 2.3)
- o During the 1970's, average labor productivity of the industries in the high technology group grew six times faster than that of total U.S. business. (See Figure 2.4)

The high technology industries accounted for more than 60 percent of total private industrial R&D, although they represented only 13 percent of the value of manufacturing product shipments. The products and processes originating in the high technology industries are dispersed across other industries, acting to enhance product quality, reduce costs and increase productivity. Notably, the non-manufacturing sectors of the economy receive significant benefits. It has been estimated that half of the benefits from R&D -- measured in terms of specific products and specific processes -- are gained by the agricultural, mining, services, etc. sectors. (See Figure 2.5) The presence of significant external, or spillover, benefits from private research and development are not surprising. It is quite difficult for the private investor in research and development to capture, or internalize, all the benefits from his investment.

The technology-intensive industries, moreover, have an important contribution to job creation -- despite the limited amount of employment within the group itself. Estimates have been made that job creation via indirect support of the high technology industries has been significantly higher than that for the economy as a whole. This is reflected in the growth figures for employment in high technology support industries over the 1970-1980 period. (See Figure 2.6)

Further, high technology products are a key element of U.S. foreign trade. The United States is unique in the relative importance that high technology goods represent in its exports. High technology products constitute a significantly greater share of the U.S. manufactured exports than of any other major economy. This has been the case consistently and has increased moderately over time. Between 1967 and 1980, the proportion represented by high technology goods has grown from under 40 percent of total U.S. manufactures to about 44 percent. For West German, France and Japan, the proportion is between 25 and 30 percent.

Of importance, also, is the fact that U.S. imports of higher technology products are becoming significant. (See Figure 2.7) Overall, U.S. two-way manufactures trade is becoming more concentrated in high technology goods.

National Security Considerations

The importance of a strong economic system to the security of the free world is self evident. The United States has a dual role, both as the principal guarantor of Western security and as the leading defender of the economic system of the free world. In this context, U.S. technological preeminance and high technology industries take on strategic importance and the maintenance and protection of a broad U.S. technological base is a vital element of national security policy. Failure on our part to maintain our technological leadership could lead to adverse consequences for the United States and for the balance of power between the Soviet Bloc and the non-communist community of nations. How we maintain technological preeminance must be carefully considered. Economic measures designed to promote an industry or sector because they can distort the operation of the market can weaken the overall economy, damaging our national security.

Advanced technology products and the industries that supply and develop them form a critical foundation for our defense capability. Consequently specific cases of trade-off between additional benefits from expanded foreign production capabilities versus the potential adverse consequences for U.S. national security may arise. Key considerations include possibilities that:

- Increased reliance, to the point of dependence, on foreign industries for significant military-related technology would heighten U.S. vulnerability. While the economic and military capabilities of Western countries might be enhanced in the short run, our long term security might be eroded.
- With the loss of leadership in key sectors of high technology, the United States will lose further control over the transfer of sensitive state-of-the-art technology to the Soviet Union.
- Ultimately, a weakened U.S. technological base might force a realignment in the relative balance of power.

These considerations must be balanced against risk that excessive and unwarranted government involvement in high technology could run the risk of weakening our position in high technology and thereby damaging our national security.

III. U.S. PERFORMANCE IN WORLD TRADE

The international competitiveness of the United States in technologically intensive industries must be assessed in relation to the overall trade position of this country, particularly with regard to the significance of changes over time and the causes of these changes. This section provides an overview of all merchandise trade as background to a more detailed examination of high technology industry trade. Selected points on specific industries are cited as illustrations of the problems facing these industries from foreign competition.

BACKGROUND

Following World War II the productive capacity of the United States relative to the rest of the industrial world gave this country the ability to compete successfully in almost any world market and in almost any commodity group. As supply capability increased in the major economies this picture changed. Overseas competitors steadily increased their proportion of markets versus the U.S. in virtually every category and location. In addition, the industrial sector in many less developed countries (LDCs) has grown dramatically over the past three decades, and has become of major importance in world trade.

Growth in foreign capacity has acted to bring a secular decline in the U.S. share of world trade. Given the disrupted and underdeveloped state of foreign economies 30 years ago, such an erosion in the U.S. share has been inevitable, to be expected, and beneficial to the United States. In 1950 U.S. GNP amounted to about one-third of total world output. By 1970 the strong growth abroad had reduced this share to some 22 percent of world GNP, -- a 35 percent decline. During the same period the U.S. share of world exports declined from 21 to 18 percent, a proportionate drop of only 14 percent.

The United States thus maintained its status in world trade more strongly than would be indicated by the relative size of the economy alone. Further, in absolute terms, the United States has remained the world's largest single trader. In 1970, U.S. exports exceeded those of the second largest exporter, Germany, by 25 percent.

Over most of the post-World War II period, moreover, a comparatively consistent relationship existed between the price of U.S. goods and foreign goods. The volume of goods exported from this country consistently obtained about the same volume of imported goods from abroad. Until the 1970's, a stable dollar versus other major currencies -- and effectively similar rates of inflation here and abroad -- resulted in similar movement of the U.S. share of trade in both current value and as calculated in terms of real quantities of goods. (See Figure 3.1)

Conditions clearly changed in the 1970's, and changed in ways directly pertinent to our consideration of high technology industries. Divergence between the U.S. export share in nominal and volume terms, as shown in Figure 3.1, reflects part of these changes.

Simply put, over the last decade the United States exported an increasingly greater volume of goods, but these goods were valued less on world markets. In effect, U.S. products in total could not command as high a price in world markets as they once did.* The decline in the value of the dollar during much of the 1970s is both a cause and a reflection of this.

What we would like to obtain is a higher price for our exports versus that of other countries. In terms of export shares, this means that we would like the nominal share (in current dollars) to be increasing over time in comparison to the volume share. Put another way, as time goes on we want the same volume of exports to exchange for an equal or greater quantity of imports.

In viewing Figure 3.1, it is dramatically clear that from 1970 on what we would have liked to have seen has not occurred. Not only have we had difficulty holding on to our volume share, but also we have only held on by reducing the value obtained for our exports (a reduction affected by the decline in the value of the dollar). We feel this is a significant change from the "to-be-expected" decline in our share of world trade due to growth of supply capacity overseas. It has direct significance to our assessment of the performance of U.S. high technology industry.

(See NOTES 1 and 2, pages 42 and 43 for detailed explanations of exchange rate effects and comparisons of trade shares.)

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* The dramatic rise in the price of oil has been a major factor in the change in relative U.S. export shares. The same pattern in real versus nominal shares is obtained, though, even if the extreme oil price changes are excluded from the calculations. In any case, higher petroleum costs are a continuing fact of life and the assessment of the current U.S. position versus 1970 cannot ignore their effect.

HIGH TECHNOLOGY TRADE

The growth in strong competition overseas has made it increasingly apparent that U.S. success in foreign markets will be hard won. If success is achieved and maintained it will have to be in those areas in which the United States has the greatest comparative advantage in relation to the rest of the world. This is desirable, of course, as the benefits of trade are the greatest if all countries can move toward specialization in what they do best.

The United States' strengths today vis-a-vis the world as a whole lie in three areas:

- Natural resources. Included here are endowments in mineral deposits, agriculture and forest acreage. The strong past and potential contributions of these resources to U.S. trade is clear.

- Wealth in existing capital. Both the U.S. productive plant and equipment, and the existing economic infrastructure -- transportation networks, communications, utilities -- are comparatively the most valuable in the world.

- Technical and scientific knowledge. This advantage lies principally in "human capital" -- the skills and knowledge of the work force -- and in a variety of institutional research facilities and traditions.

This third factor, as we have discussed, is characterized by industries with vigorous growth and influence which reaches into all areas of the economy. To varying degrees, technological advances can sometimes act to substitute for inputs of natural resources and physical capital stocks. Further, of the areas of U.S. comparative advantage, it is one that can most readily be eroded (both by developments overseas and decline in the U.S.). Technology is transferable (mobile) when sufficient skills and knowledge exists in the recipient country's populations; where skills and knowledge are deficient, the mobility of technology is impeded.

Technical and scientific knowledge is translated into technological advances. These advances significantly effect our future success in world trade. What then can be said about the performance of our technology-intensive industries in recent years, and about their prospects for the future?

Assessing High Technology Performance

A variety of trade statistics have been examined to assess high technology industry performance, many of which are presented in the following discussion or in Appendix B. We recognize, though, that there is no single method to test the competitiveness of a group of industries as complex and diverse as the high technology sector.

Further, there are questions concerning the performance of these or any other industries which are essentially unanswerable -- such as: What level of competitiveness is enough?; and, What share of a market is too little?

The United States will face an intense struggle for markets in the future. Even if industries have performed relatively well, they should not be hampered by either old or new barriers that prevent an even better performance.

In this light, the appropriate questions to be addressed are the following:

- Does the decline in the market share of U.S. high technology industries represent a natural evolution from a position of dominance that is of no concern, or is there reason for concern?

- Are there significant indications that the trend will continue?

The answer to both of these questions, we believe, is yes.

Competitive Trends

Aggregate Market Share -- Aggregate measures of trade performance in technology-intensive products include export market share. This indicator -- a country's exports divided by the sum of other countries' exports -- shows a growing importance of other countries' products versus those of the United States.

From 1962 through 1980 the U.S. share of industrial country high technology exports as a group declined. (See Figure 3.2) The share of each of our major competitors increased. For Japan, dramatic gains took place, with a 4.2 percent share rising to 12 percent by 1980. (Japanese export success reflects in part the lower inflation adjusted value of the yen since 1974. The real value of the yen fell nearly 20 percent between the beginning of 1975 and the end of 1981.)

The greatest gains by Japan took place in the form of increased high technology exports to the major economies themselves. German and French gains were strong in third country markets, that is, other than the U.S., German, French and Japanese markets. The United States has traditionally been strong in the third country area, but experienced a significant share reduction in these markets as well. (See Figure 3.3)

Disaggregated Market Share -- Examining market share performance by more disaggregated high technology industries indicates a similar pattern for the United States. For the ten technology-intensive industries examined, only two -- representing some 15 percent of U.S. high technology exports -- showed an increase in exports relative to similar industrial country exports for 1965 versus 1980. (See Figure 3.4) Of these two, only one -- agricultural chemicals, (some 4 percent of U.S. high technology exports) -- showed an increase in share between 1970 and 1980.

Moreover, as can be seen in Figure 3.4 (where the width of the bars represent relative industry size in total industrial country high technology exports), the industries which have the larger shares in world trade are not those where the U.S. share has increased. The opposite has been the case.

Technology-Intensive Trade Balances

The U.S. overall trade balance in high technology products increased from 1962 through 1980. Japanese, German, and French balances also grew. (See Figure 3.5) The U.S. surplus remained the largest, although the relative growth in the Japanese surplus was the most rapid.

Dramatic change in the Japanese competitive position in high technology surplus is also indicated in their expanding bilateral balance with the United States in high technology trade. (See Figure 3.6) From a deficit in these products in 1968, Japan has moved to a surplus position vis-a-vis this country of nearly $3.0 billion in 1980. This surplus -- about one seventh of Japan's global high technology trade surplus -- is about equal to the U.S. combined surplus in these products with France and Germany.

The trade surplus generated in high technology products is significant for the United States. Nonetheless it should be noted that a substantial portion of this surplus has been due to only two industries. In 1980 more than 50 percent of the U.S. surplus in high technology products was from aircraft and computer-related trade alone (these two sectors rank among the highest technology intensity in terms of the industries identified as high technology). This proportion, moreover, has increased since 1965, indicating that the other high technology industries have been relatively less successful in the combined domestic and international market. (Two of the ten industries, in fact, posted trade deficits in 1980.)

Changes in Relative Trade Advantage

Changes in relative trade performance between industries within the same country provide additional information on the status of high technology industries. A specific indicator useful for this examination is a country's "revealed comparative advantage" -- the ranking of industries according to their market share versus the average market share for the country. This measure, which is presented for industries of the four major countries in Figure 3.7, is simply the export market share of an industry divided by the country's total export market share. (In Figure 3.7 the radius of the circles represents the average market share. Industries falling inside the circle thus have less than the country's average share of world markets, those outside have greater than average.) Examination of changes in these measures over time indicates practical differences in country specialization in trade.

Three points are emphasized by changes in industry versus average export shares for these countries. First, there are considerably greater differences in country market shares for the United States and Japan, than in the other two countries. Germany and France's industry market shares are generally near to the country average (and thus fall near the circle in Figure 3.7), with little major alteration in this pattern between 1965 and 1980.

Secondly, in the U.S. and Japan the differences existing in market shares for different industries have increased further -- sometimes dramatically -- between 1965 and 1980. Most notable have been increases in aircraft, computer, and agricultural chemical industries in the United States, and the electrical equipment, optical/medical instruments, engines/turbines, and automotive industries in Japan.

The third point of major interest is the degree to which increases in relative advantage within the Japanese ranking are matched by reductions, or little change, for those industries' relative advantage in the United States. This is particularly apparent with regard to the electrical components and instruments industries within the higher technology sector.

The suggestion made by this third point is the possibility of the past Japanese predominance in radio, TV and automobile exports being duplicated in other sectors. In this case, the measures of increased relative advantage in Japan -- those for electronic components, instruments, engines and turbines, and computers -- which are shown in Figure 3.7 suggest much tougher future competition in these areas.

INDUSTRY-SPECIFIC CASES

An examination of individual industries and products provides further information on the performance and prospects for U.S. high technology trade. Key points for a variety of selected cases -- examined at a level of greater detail than is possible for the total high technology industry list discussed so far -- are outlined below. (Further information is presented in the Appendices.) In all of these sectors the United States has had at one time or another, technological leadership. These cases illustrate how this past situation of U.S. dominance has changed. They also illustrate the increasing presense of foreign government programs in the areas of commercial research and development. How substantial and effective these programs are varies across the different sectors. Some government supported programs such as those in aircraft and semiconductors have clearly influenced the competitive status of foreign firms.

Aircraft

The U.S. civil aircraft industry has traditionally dominated world markets. As late as the mid-1970's, U.S. manufacturers held 95 percent of the world's orders for large transport aircraft. Since 1975, however, foreign competition has intensified.

- The principal source of competition is from the government funded European consortium Airbus Industrie, which captured roughly a quarter of the jet aircraft market in 1981. Over half of the announced new orders for wide-body aircraft have been captured by Airbus.

- o The relative level of U.S. aerospace R&D funding has steadily declined because of decreased federal funding. Foreign R&D capabilities, most of which are government funded, have expanded.

Space - Aircraft and Parts

By the mid-1980's, estimated requirements for U.S. commercial space launch service will exceed the capacity of the approved shuttle fleet. Present policy (being reexamined) calls for a phase out of expendable launch vehicles that could augment the shuttle capacity. The French, with their Ariane launch vehicle, have initiated an aggressive marketing campaign to secure a major segment of this traffic.

- o Civil space activity in the United States is the responsibility of the National Aeronautics and Space Administration (NASA). Commercal payload launch dates are established by NASA through agreements with customers. National security payloads, now launched on expendable vehicles, will depend on the Space Shuttle in the late 1980's.

- o Fixed prices of U.S. launches are set by NASA, rather than through commercial negotiations between launch customer and launch vehicle suppliers. Current policy requires full cost recovery for expendable launch vehicles. In the post-1985 period, Space Shuttle launches will recover all "out-of-pocket" costs to NASA. The French Arianespace organization is able to offer the customer more favorable financing terms than NASA, both because of subsidy by the French Government and because incorporation as a commercial venture permits flexibility not presently available to NASA.

- o The evolution of expendable launch vehicles has slowed as NASA's major attention and funding has been toward the development and deployment of the Space Shuttle. Though there is a fledgling initiative by U.S. private interests to develop a competitive expendable launch vehicle.

- o The French Ariane, although now using technology similar to that developed for U.S. vehicles two decades ago, will undergo considerable and rapid evolution to meet the needs of the commercial satellite industry.

- o The Japanese are putting up satellites, are developing their own launch vehicles, and in time could assume the launch support role for commercial satellites.

- o The Soviet Union has launched a foreign system commercially for the first time and could also become a competitor.

Computer Hardware and Software

The United States retains broad leadership in computer hardware and software production and technology. But, the Japanese have begun to close the gap in a variety of sectors.

- o Japanese producers now have products that match or exceed the capabilities of major U.S. producers in such sectors as large-scale processors, magnetic disk storage and printers. Joint government-industry research efforts are focusing on software, in which the Japanese lags U.S. firms in most areas.

- o The Japanese government and industry have targeted the scientific computing or supercomputer sector, and the leading Japanese producer recently announced a computer which it claims surpasses current U.S. models in this sector.

- o In concert with industry, the Japanese government has begun a 10-year R&D program to produce the so-called "5th generation" computer system, by which they hope to leapfrog the U.S. industry.

Semiconductors - Computers and office machines, Electrical equipment and Components

The United States no longer has the lead in several important areas of semiconductor technology.

- o Japan has an emerging leadership role in metal-oxide semiconductor (MOS) high-density computer memories. It now has well over 50 percent of the world market for the current state-of-the-art device.

- o The Japanese also have strong capabilities in complementary metal-oxide semiconductor (CMOS) technology, favored for its low power, radiation resistant characteristics.

- o Japan has an emerging semiconductor production equipment technology which will rival U.S. capabilities. Emphasis is on increasing the degree of automation of production facilities as well as improving its ability to produce high density devices.

- o The Japanese, West German and French governments have subsidized a number of programs to assist their microelectronics industries.

- o The United States retains a firm lead in microprocessor technology.

Fiber Optics - Electrical equipment and components

Fiber optic technology has advanced rapidly since the late 1960s, with a significant potential range of applications, especially in the communications field.

- o Of the three components in a fiber optics system -- light source, transmission medium, and detectors -- Japan has been credited with a clear lead in light source technology and application and is competitive with the United States in the other component technologies.

- o Japan's Ministry of International Trade and Industry has targeted optoelectronics for rapid development. The Engineering Research Association of Optoelectronics Applied Systems was established in 1980 to be the coordinator of government-subsidized projects in fiber optics and other optoelectronic R&D projects.

Biotechnology - Drugs and Medicines, Chemicals (biogenetics)

Although the United States has the lead in recombinant DNA and cell culture technologies, there are gaps in its process technology and in the manpower available to meet future needs.

- o Other nations are making substantial investments in the commercialization processes, in which the United States has no clear lead.

- o Japan has an undisputed lead in fermentation processes, a critical segment for commercialization, and is aggressively seeking to build on its strengths in this area.

Pharmaceuticals

American domination of world pharmaceutical markets has been steadily reduced over the past twenty years.

- o In the antibiotics sector, Japanese manufacturers are the world leaders in new compounds. Seven of eleven new antibiotics developed in 1979 originated in Japanese laboratories.

- o Expenditures of U.S.-owned companies for research at home and abroad have not matched the expansion of foreign-owned firms' research efforts.

- The U.S.-located share of world pharmaceutical research has fallen from about two-thirds in the early 1960's to just above one-third today -- higher growth rates for West Germany, Japan, and the U.K. have persisted.

Robotics - Computers and office machines, Electrical equipment and components

While the United States continues to lead in research and design, Japan has far surpassed it in robot production and use. According to a narrow U.S. definition of robots, which excludes simple mechanical transfer devices, Japan currently has about three and a half times as many robots in use as the United States.

- Starting with technology licensed from the United States, Japanese manufacturers have developed robots for a broad spectrum of applications. Over 70 percent of all robots used in Japan perform machine tool loading and assembly operations, compared with 21 percent in the United States. Japan's experience in this area, which is expected to be a major growth market, will give it an advantage in the U.S. market.

- Several U.S. firms have entered into licensing arrangements with foreign companies to attempt to accelerate their own entry into the robot field.

Machine Tools* - Computers and office machines, electrical equipment and components.

- The competitiveness of the machine tool industry will increasingly depend on the use of microelectronics and computer-based technologies, areas of increasing activity overseas.

- Other countries, particularly West Germany and Japan have actively penetrated the U.S. machine tool market. Imports now account for 24 percent of U.S. consumption.

- Japan has developed a major capability in computer numerically controlled (CNC) machines and flexible manufacturing systems (FMS). Japan has already made inroads in the U.S. CNC market and has targeted FMS for mass marketing.

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*While the aggregate machine tool sector technically falls outside the definition of high technology, a number of segments of the industry are intensive consumers of new technologies.

THE U.S. HIGH TECHNOLOGY POSITION

The United States maintains an absolute lead in overall technology. Nonetheless, there has been a decline relative to our major competitors in a significant number of U.S. high technology industries. This change must be considered in conjunction with the following:

- The importance of technology as a key factor of U.S. comparative advantage in trade -- particularly considering the secular decline in the aggregate U.S. trade position;

- The value of technology-intensive industries -- in terms of growth potential, and their high wage, low pollution characteristics -- as a desirable area of economic activity; and

- The signs of concentrated foreign efforts to become major competitors in technology-intensive products.

The degree to which specific factors have affected the competitiveness of the country's industries -- and may continue to do so -- is discussed in the following Section.

IV. THE ENVIRONMENT FOR TECHNOLOGICAL DEVELOPMENT: FACTORS CONTRIBUTING TO COMPETITIVENESS

Among a large variety of economic, social and political forces, several key factors have a significant influence on technological development and the competitiveness of virtually all U.S. technologically-intensive industries. This section examines these principal elements, contrasting their significance to the United States and major foreign competitors.

We believe that among the most important factors which influence competitiveness in high-technology industries are*:

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*Exchange rate movements can have and have had an influence on the competitiveness of high technology industries. But there are several reasons for not identifying them as an element affecting competitiveness across a broad range of high technology industries. A number of high technology segments are only emerging industries, robotics and biotechnology, for example. Trade is not significant. Even for some of the more established high technology sectors international flows may take the form of technology rather than products and, therefore, are relatively insulated from the effects of movements in exchange rates. Another factor dimishing the influence of exchange rates is the widespread phenomenon of rapid price declines for high technology products, in some instances, of sufficient magnitude to dominate any movements in exchange rates. For these reasons we do not identify exchange rate movements as a principal element affecting the U.S. competitive position across-the-board in high technology.

-- General economic policies including competition policies and their effects on growth and the investment decision;

-- Financial capital cost/supply;

-- Explicit R&D programs and incentives;

-- Supplies of skilled personnel;

-- The transfer of technology to other economies; and

-- Explicit industry policies, including targeting strategies and trade restrictions.

In the following, these major elements are discussed in some detail.

The relative importance of each of these considerations may vary significantly among industries. We do not intend that this assessment should downplay the importance of other individual, detailed considerations which are highly industry-specific.

The high technology industries are characterized by relatively rapid technological development and changing market attributes. No precise analytic method exists for determining the effect of a each one of these factors in isolation on innovative performance for a group of industries as a whole. In large part, they act in concert. Stable noninflationary growth stimulates the demand for new innovation, but it could not be fully attained without adequate skills embodied in scientists and engineers, and adequate R&D expenditures. New innovation could not be applied without access to financial capital at competitive rates. Conversely, technology transfers would be more likely to take place if skills, capital and demand were limited in the domestic environment. Interactions between a number of these factors must also be recognized, further complicating the analysis.

THE OVERALL ECONOMIC CLIMATE AND HIGH TECHNOLOGY INDUSTRIES

Innovative activity and the willingness to apply technological advances are directly and substantially affected by the general economic environment and government macroeconomic policies.* During recession, among the first areas to be cut back by firms have historically been investments in research and development and other long-term innovative activities. Thus, to increase investor willingness to undertake high-risk investments with long-term paybacks, it is important to reduce uncertainty through:

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*Additional discussion of the influence of these factors can be found in Appendix D.

- o strong and steady economic growth;
- o low and predictable inflation; and
- o consistent government macroeconomic policies.

Before the 1973-74 oil price increase and the world recession that followed, the general economic environment was favorable to research and development, innovation, and capital formation in the United States, Japan, West Germany, and France. Strong and steady economic growth maintained investor confidence in the potential return to investments in innovative activities. Inflation averaged 6 percent or less annually and remained fairly stable, which prevented the erosion of real-value historic-based depreciation allowances and provided a more stable planning horizon regarding future costs and prices.

Government macroeconomic policies indirectly supported private investments in innovative activities. Government revenues and expenditures grew more slowly than incomes, leaving increasingly larger shares of incomes at the disposal of the private sector. Only in the United States did this phenomenon fail to occur, and in the two decades starting in 1960 expenditures slightly outpaced overall income gains. Budget deficits of the four countries, in general, did not crowd out private capital expenditures or push interest rates upward.

The oil price increase and the world-wide recession unfavorably altered the economic environment in all four countries, though less seriously in Japan. For the last half of the 1970s:

- o the rate of expansion of real economic activity slowed sharply in all four countries,
- o the rate of inflation increased in all but Japan, and
- o government economic policies became more volatile and lacked consistency as they switched between fighting inflation and maintaining high employment.

Confidence in the strength of Japan's economy was adversely affected by the sudden 5-6 percent drop in its real growth rate in 1975. Nevertheless, the steadiness of the rate in the late 1970s -- the real GNP growth range was 4-6 percent a year during 1976-80 -- restored the confidence of Japanese businessmen in the fundamental soundness of their economy. Even in 1981, a relatively dismal year for most industrial economies, Japan had 3.0 percent real growth. Each of the other countries had greater variations in real GNP growth in 1976-80, and only the United States and Japan had substantial real growth in 1981.

Post-1975 inflation rates have been more favorable in Japan and West Germany. Despite the international tendency toward inflation, both countries' price increases in the last half of the decade were below those between 1960 and 1973. These lower rates of inflation indirectly promoted investment by helping to hold down interest rates.

In part, the relative shifts in macroeconomic performances in the late 1970s were conditioned by government economic policies. Some governments clearly chose to combat actual and latent inflationary pressures more strongly than problems arising from slower economic growth or recession. And the monetary authorities in some instances held growth of the money supply to rates well below previous levels combat inflationary tendencies.

The recent emphasis on lowering the rate of inflation and eliminating the use of "stop-and-go" economic policies by the U.S. government is expected to provide a more conducive climate for innovation in the United States. The decline in the underlying U.S. inflation rate combined with dramatic decline in interest rates and the recovery of the stock market suggest a movement toward a more favorable economic environment.

FINANCIAL CAPITAL COST/SUPPLY

The Role of Financial Capital

High technology firms generally compete in rapidly expanding markets that can change quickly with the introduction of new products or processes. The ability to quickly respond to new opportunities is essential. International differences in the availability of financial capital may be crucial in determining relative competitiveness in specific areas.

All technology-intensive industries are not necessarily among the most capital-intensive industries within an economy, particularly in terms of physical capital per worker. There is, though, a significant requirement for financial capital -- that is funding for research, development and operations occurring before sales take place -- in most of the high technology industries.

The requirement for financial capital is directly tied to the nature of many high technology concerns. New opportunities in terms of product or process are often created for the first time by costly fundamental research carried out with no guarantee of return to the investment. The application of new technology in a production system often requires substantial capital. Finally, the growth in sales may be initially slow and require financial support because the product may have been created before the explicit demand for the item existed (i.e., "we wanted it but didn't know it").

In this context, the cost of financial capital can have a particular effect in comparison with other costs of production for technology-intensive firms. High capital costs can preclude endeavors which have high risks but potentially great returns for the entire society. Further, we feel that the policies of our major competitors can have notable influences on the relative cost and availability of capital in a number of technologically-intensive areas. Many of these are related to industrial policies which are described in other sections of this report. Principal characteristics of foreign financial systems in which such policies operate are outlined below.

Financial Systems

Japan -- Japan's success in high technology competition has been partly due to the incentives and benefits of its government's guidance through its financial system, including how it has administered its tax policies. Government control of Japan's financial system remains tight despite the steps taken in recent years to liberalize. Even though Japan's direct contribution to the development of its high technology industries has been more limited in the last few years, its high technology efforts continue to have a significant impact on the development of those industries through financial policy instruments such as interest rates, tax incentives and loan programs. (For more on the latter, see the section on industrial policy.)

After World War II, Japanese firms satisfied their large demand for funds through bank borrowings. In turn, banks funded corporate demands through heavy borrowing from the Bank of Japan. This set of relations gave the monetary authorities tremendous leverage over the financial system. Reinforcing this leverage, an extensive array of capital controls insulated the Japanese financial system and interest rate structure from foreign money market developments, and the government rationed credit on a preferential basis to promote development of targeted economic sectors. A corollary of this pattern of financial development was that Japanese bond and stock markets were underdeveloped.

The authorities' leverage over the financial system began to erode after the first oil crisis, due to declining demand for bank credit in view of slower economic growth and increasing corporate reliance on overseas fundings and retained earnings. Concurrently, the authorities recognized the need to move toward a market-oriented environment to finance current account and budgetary imbalances and to implement monetary policy via open market operations. Although the large growth in government bond issues to finance budgetary deficits has resulted in the emergence of a sizeable Japanese bond market, this market trades mainly government bonds and not private corporate issues. The Japanese stock market is still characterized as volatile.

Thus, in recent years Japan has replaced administered interest rates for most key money market instruments with market oriented rates and revoked most prohibitions on external capital flows. However, some external controls remain; and certain domestic deposit and lending rates, and as well as primary market issues of government bonds are still under administrative control. These controls and allocation of loan funds to corporations through "window guidance" are used by the government to extend preferential credit to certain sectors and industries to fulfill social and economic objectives.

Japanese central bank rate supervision has kept interest rates below market clearing levels. As a result, the major city banks periodically need Bank of Japan refinancing, and thus become subject to government guidance on allocating loans among industries. This encourages the banks to make loans to targeted borrowers -- those firms integral to the accomplishment of the Ministry of International Trade and Industry's vision of industrial development -- enabling those firms to sustain unusually high debt levels. Furthermore, most commercial bank lending is short-term, but explicit or implicit rollover agreements allow Japanese corporations to view short-term loans as long-term liabilities.

Japan's tax policies have been particularly helpful to the development of their high-technology industries in general and for specifically designated industries such as microelectronics and computers. Most importantly, their high technology industries have been aided by both general tax provisions that provide exemptions for capital gains and personal income tax exemptions which have encouraged high levels of savings and investment. They have also been aided by special tax provisions that encourage high technology development through accelerated depreciation, as well as one-time write-offs for purchasing designated Japanese produced equipment such as computers, tax reserve funds that allow tax deferral, and tax credits on specified types of investments. The combined effects of these subsidies has been very important. This is demonstrated for example in the magnitude of the national tax revenues lost just under the category of promoting technology. In 1981 alone this loss amounted to over $600 million, or over one-fourth of all Japanese national tax benefits granted.

France -- The inefficient and poorly developed French capital market reflects the pervasive influence of the central government in controlling economic activity and its desire to ensure the availability of long-term capital for selected, favored corporate investment despite a chronic shortage of long term capital. It is characterized by an extremely complex set of financial intermediaries, most under government control, which together channel household savings into corporate investment.

French firms depend heavily upon bank lending to supplement internal funds. In 1970-79, financial institutions supplied over 75 percent of the funds French corporations raised domestically. The market for stocks has traditionally been limited, while the bond market has been dominated by the nationalized industries and special credit institutions.

The Banque de France closely controls the amount and cost of capital available to firms. As in Japan, commercial banks rely on central bank refinancing of medium- and long-term industrial loans and are thus subject to administrative guidance.

Citing French commercial bank caution in lending, the relatively high interest rate to corporate borrowers, and the excessive weight accorded short-term profits in deciding among potential borrowers, the Mitterrand government has introduced legislation that will result in a nationalized banking sector directly or indirectly controlling 97 percent of all resident deposits and 93 percent of all loans. The government expects that this additional control will enable it to ensure that lending criteria are adjusted in favor of long-term investments judged to be in the national interest.

West Germany -- The West German financial system is characterized by a high level of personal savings, and a high degree of industry financing by retained earnings. The ratio of internal resources to gross investments has ranged from 70 to 90 percent over the past 20 years. The banking system's crucial role is to attract long-term deposits and reloan them to industry. In 1970-79, roughly 80 percent of external corporate financing was in the form of fixed-interest loans for ten years or more.

The interlocking relationship between the financial and industrial sectors in West Germany is the strongest among the major economies. In 1980, banks voted an average of 63 percent of the corporate shares voted of the 74 largest West German corporations. The three largest banks alone accounted for 35 percent of the shares voted.

As financial advisers and holders of voting rights of such significance, German banks can have considerable influence over a firm's behavior. This influence contributes to decision making consistent with long-term return to capital and, thus, the ability to reduce the extensive long-term bank exposure. The firms benefit from the information bankers are able to bring to their board rooms and from the greater degree of certainty that financial support exists for corporate decisions.

While West German banks often play a major role in corporate decision making by virtue of their major equity holdings, the central government has not employed the financial system to guide lending activities. Financial policies are generally macroeconomic, with specific lending institutions providing sectoral assistance, primarily to housing.

Nonetheless, to emphasize investment as a means of stimulating the economy, the West German government has sponsored a number of programs to compensate for perceived capital market deficiencies. For example, it has attempted to compensate for the virtual absence of venture capital and the reluctance of commercial banks to finance small- and medium-sized firms by the use of a government sponsored independent organization formed by a consortium of banks with the goal of providing venture capital for high-risk projects.

Sources of Funds

Internal cash flow has significant advantages as a source of funds for innovative activity. Industry structure, corporate tax policies, sales volume, profit margins, and investor demand for a return on investment strongly influence the generation of internal cash flow. External funds are raised through stock issues, bond sales, and borrowing. Host financial markets and a corporation's relationship with its lenders greatly affect both how these funds are raised and corporate reliance on them. Normally, firms are hesitant to externally fund high-risk projects, especially if the payoff may not be realized for a number of years.

An important development influencing innovative activity, therefore, has been that external financing in the United States has increased significantly compared with internal funding. The relative importance of these two sources has been reversed within the past decade. (See Figure 4.1)

The U.S. household sector is a net provider of funds to the business and government sectors. In previous years the U.S. saving rate has been substantially below that of its competitors. A comparison of average personal saving rates for the 1976-80 period reveals a great disparity: Japan, 20 percent; France, 16 percent; West Germany, 14 percent; and the United States, 6 percent. While part of the difference may be attributed to cultural and institutional differences, one factor historically has been the insufficiency of incentives for increased savings.

The U.S. system is further characterized by substantial direct acquisition of capital through equity financing and borrowing, principally from the household sector. U.S. corporations have relied relatively less on debt as a source of funds than have their foreign competitors. (See Figure 4.2) As a result, they may have tended to put more emphasis on short-term profitability in assessing investment programs.

Assessment of the Relative U.S. Position

Examinations of the practical effect of our major competitors' economic policies indicate that industry preferences in capital cost and availability have existed. Tax policy, to special reserve accounts, has been one mechanism employed in this regard. For example, in some cases, special reserve accounts have been used effectively as an interest-free loan from the central government providing additional maneuverability by lowering corporate demand for external funds:

- In Japan special reserve allowances have also been legislated to encourage specific corporate undertakings, such as the application of computer-aided design and robotics.

- By the end of 1978, "reserves and provisions" uniformly comprised almost two-thirds of French and Japanese and one-third of West German equity holdings. Moreover, foreign firms have uniformly experienced a continued growth in allowable reserves and thus benefited from a constant stream of tax-free income.

The financial markets in Japan and France are organized to make low-cost financial capital available to favored industrial sectors. The French and Japanese governments especially emphasize the use of their banking systems to influence the pattern of industrial growth. While these policies may not necessarily result in the most profitable or the most productive use of financial resources within these economies, such actions can significantly affect the cost and supply of capital for specific foreign firms relative to U.S. counterparts.

Relative Cost -- We believe that some specific high technology industries may have faced effectively greater capital costs here than abroad. This has been due to the combined effects of preferential treatment afforded specific foreign firms in obtaining capital at favorable rates and foreign government policies which in effect act to reduce the risk of an industry project -- and thereby the premium which must be paid for capital on this account. On the other hand, non-favored firms abroad may have faced higher costs, or found capital less available.

RELATIVE RESEARCH AND DEVELOPMENT EFFORTS

Both government and private industry support high technology by sponsoring research and development programs. An examination of trends in R&D in the United States, Japan, West Germany, and France reveal significant changes in overall relative growth in real R&D expenditures and in how those expenditures are allocated among the different types of research. It also shows a dramatic increase in U.S. industry's share of R&D spending, along with the U.S. government's strong shift from defense-related to civilian projects over most of the 1960s and 1970s with a projected reversal of this pattern in the future. THe U.S. defense establishment absorbs a significant proportion of U.S. research and development spending. Among OECD contries, U.S. defense related R&D spending is over three times the combined level of all other governments. Most of the foreign government sponsored R&D focuses on areas of potential commercial significance.

Overall R&D Funding

In absolute terms, the United States supports the largest amount of R&D. In 1977, for example, U.S. private funding of industrial R&D was about 40 precent greater than the sum of the corresponding figures for Japan, West Germany, and France. But since 1964, R&D funding from all sources has increased more rapidly in these three countries than in the United States. (See Figure 4.3) These differences in growth reflect in part, a growing willingness by these other countries to invest a constant or increasing proportion of their gross domestic output in R&D. Further, these expenditures are focused on areas where these investments become significant relative to U.S. efforts.

There have also been significant changes in allocation of R&D spending among basic research, applied research, and development across the four countries. Starting from a relatively low base, between 1967 and 1977, in real terms, Japan increased its proportion of R&D funds for basic research by over 60 percent, West Germany by over 50 percent, and France by over 16 percent. (See Figure 4.4) The proportion of U.S. spending, adjusted for inflation, allocated to basic research, however, remained constant throughout the period. The U.S. government funds approximately 70 percent of all basic research performed in the U.S.

Business R&D Funding

With regard to business funding of R&D, U.S. performance compares favorably for the 1970s. Between 1964 and 1970, firms in West Germany and France expanded their R&D funding at substantially higher rates than U.S. firms. During the 1970s, however, growth in U.S. business funding of R&D surpassed that of West Germany and almost matched the French growth rate. Meanwhile, starting from a lower base R&D spending by Japanese firms grew over 50 percent faster than that of U.S. firms. (See Figure 4.5)

A look at the share of business gross domestic output apportioned to R&D for manufacturing activities also shows a comparatively strong U.S. business performance. (See Figure 4.6)

Because the United States is increasingly relying on private business to fund research, a greater share of U.S. research will be influenced by the pressures of the market. For example, a recent trend has been for U.S. businesses to favor research projects with short-term benefits relative to those with long-term benefits. This change in favor of shorter-term projects is partly the result of the volatile U.S. rates of inflation and, some observers believe, managerial incentives and techniques. Thus, projects with long-term economic and social benefits tend to be underfunded. It is widely recognized that the social returns to research far exceed the private returns, thus the changing structure of sponsorship of R&D in turn influences the composition of the projects undertaken.

A recent study by the McGraw-Hill Company shows that, unlike during previous recessions, R&D expenditures by U.S. firms are expected to increase substantially in 1982 over 1981 (up 17 percent). The new tax provisions and competition from Japan are believed to be particularly responsible for the unusual increase. However, the survey provides no evidence concerning the time horizon of these investments.

Government R&D Funding

Governments in all industrial nations fund R&D for at least three purposes:

- o to meet government needs (e.g., defense);
- o to enhance the science and technology infrastructure (scientific knowledge, training of scientists and engineers); and
- o to stimulate development of commercial technologies (in the United States, the major beneficiaries of this type of research support have been agriculture and energy).

The four countries show major changes in government R&D funding patterns during 1964-78. These differences may well have influenced these countries' rate of development of commercial technologies during the past ten to fifteen years.

From 1964 through 1978, real government R&D expenditures in the United States declined by approximately 9 percent. (See Figure 4.7) During 1964-70, the governments of Japan, West Germany, and France greatly increased their R&D spending, while from 1970 through 1978, only Japan and West Germany continued this rapid expansion, with real growth of 66 and 30 percent, respectively. Recently France has announced a goal of greatly increasing the resources devoted to R&D.

The major proximate factor in the decline of U.S. government spending for R&D was the sharp cutback in defense and space R&D during the late 1960s and early 1970s. (See Figure 4.8) At the same time, other major components of U.S. government R&D did not increase enough to completely offset this reduction. Current budget projections, however, show a relative R&D expenditure shift back to defense. Combined with the private sector increases, this will signify a relative change away from civilian R&D support.

In contrast, the governments of Japan, West Germany, and France accelerated their R&D efforts in several areas during the 1970s seeking to achieve maximum impact on commercial technologies in order to narrow the U.S. technological leadership in key sectors. For example,

- all three countries increased their R&D outlays for nuclear energy programs;

- Europeans nations, led by France and West Germany, undertook a space satellite program and development of the Airbus;

- in France and Japan, the governments allocated substantial funds for electronics R&D.

However, in 1981 the U.S. government sponsored almost half of all R&D conducted in the United States, about $32.9 billion, and real growth of approximately 4 percent is estimated for 1982. Of this amount 52 percent went for national defense, 14 percent for space, 11 percent for health and 10 percent for energy. The scale and relative support for military R&D is unique. Outlays for R&D by our major trading partners tend to focus on projects with significant payoffs in the commercial sphere.

In 1980, the last year for which international data are available, the U.S. government expenditures for R&D, $29.6 billion, were a third greater than those of Japan, West Germany and France combined ($22.2 billion). The Japanese government sponsored 25 percent of all R&D conducted in Japan in 1980, about $5.7 billion; the West German government sponsored 48 percent, about $9.1 billion; and the French government sponsored 62 percent, about $7.4 billion.

SCIENTIFIC AND TECHNICAL PERSONNEL

Although representing only 5 percent of total employment, the high technology industries accounted for more than 25 percent of total U.S. scientific and technical manpower in 1980.

The availability of large numbers of well-trained scientific and technical personnel has long been recognized as a significant contributor to the competitive strength of American high technology firms. Recent trends, however, reveal that not only is this relative advantage diminishing, but the relative quality of the U.S. technical pool may also be declining.

The following trends during the 1970s illuminate the problem:

- Employment of scientists and engineers in R&D rose considerably more rapidly in Japan, West Germany, and France than in the United States. (See Figure 4.9)

- The percentage each country contributes to the total number of scientists and engineers employed in R&D across all four countries illustrates the significant changes in relative positions. Japan moved up to almost 25 percent from 20 percent of this total, while the U.S. proportion declined from 63 percent to 57 percent.

- When examined against labor force trends, these relative changes become even more significant: the labor force in the United States grew by 24 percent; in Japan, by about 6 percent; and in France, by roughly 5 percent. In West Germany, it actually declined by 6 percent.

- There has been a noticeable "graying" of America's engineering work force as the percentage of younger engineers in the pool has fallen. Since the obsolescence of knowledge occurs rapidly, espcially in areas where R&D is extensive, an aging engineering work force is likely to be less creative.

As a result of these trends, during the 1970s, the U.S. labor market was characterized by shortages of personnel in several high technology specialties. Most prominent among the shortages or tight labor market conditions reported during this period were those for all types of computer specialists. This reflected the burgeoning applications of computers and their related servicing industries throughout the economy. Similar situations were reported for electronic specialists and chemical, electrical, and industrial engineers.

The increases in salary levels in the private sector, which resulted from a tight labor market, seriously affected recruitment of instructors for U.S. engineering school faculties (currently, there are 1,600 vacancies) and for the U.S. armed forces (where pay scales did not keep up with the private sector). These increases also contributed to a sharp drop in the number of engineering Ph.D. candidates.

Upgrading the Quality of Science and Engineering Education

The quality of secondary and postsecondary education programs will be important to the competitive positions of the advanced economies. Not only with respect to enhancing the education of future engineers but also to upgrade the skills of the existing work force. In the past, U.S. industry has made less use of the option of upgrading the skills of older personnel than its foreign competitors, whose governments encourage systematic upgrading.

Although the United States retained a substantial, if reduced, overall lead in the employment of scientific and technical personnel, the relative upgrading of the quality of the overall labor force was greater in the other countries, particularly in Japan.

United States--The lack of universally high standards in mathematics and the sciences in U.S. secondary schools, along with a lack of emphasis on these disciplines, seriously handicaps attempts to broaden the U.S. base for training scientists and engineers. This has also been cited as a major factor in the relative decline of the "technological literacy" of the U.S. labor force in general.

At the university level, however, the United States remains strong. Education in science and engineering at U.S. universities compares very favorably with postsecondary education in competing nations. The relative adaptability of the U.S. engineering schools, as compared with their foreign counterparts, has been a strength. For these reasons, U.S. universities enjoy a strong international reputation and attract large numbers of foreign students. Still, the previously mentioned faculty vacancies do raise questions about the ability of U.S. universities to provide quality engineering education in the future.

Japan--The Japanese have a policy of emphasizing scientific and technological training. The strong background average Japanese factory workers have in science and mathematics is one explanation of their superior understanding of the technological aspects of production.

Scientists and engineers enjoy a very high status in Japan. This has been reflected by the 65 percent of the baccalaureates who opt for scientific fields at the university level (as contrasted with 30 percent in the United States).

The relationships among universities, the government, and industry are very close in Japan and mostly maintained by informal channels.

West Germany--West German secondary education for those heading for universities also has much more required training in mathematics and sciences than U.S. schools. About 75 percent of those who graduate from the upper secondary school go on to universities, and roughly one-third of this group seek degrees in science, engineering, or mathematics.

France--The highly centralized French educational system has rigid secondary school requirements in mathematics and science studies for those planning to enter higher education. Those entering higher education either go to the very select Grandes Ecoles, for which the competition is very great or to ordinary universities. Despite the rapid expansion in requirements for engineers in France, the Grandes Ecoles have not been allowed to expand significantly.

Graduates from the select French engineering schools are destined for careers as administrators in the government and industry, while those with degrees in the sciences or engineering from ordinary universities do not carry such a guarantee to success.

GOVERNMENT INDUSTRIAL POLICIES IN HIGH TECHNOLOGY SECTORS

In adopting industrial policies for high technology sectors, governments usually state as their principal objective the identification and acceleration of activity in potentially strong sectors to gain larger shares of international markets. In some countries, these policies lead to the government's selecting "national champions" or strengthening state-owned enterprises to be used as the competitive leaders.

Foreign industrial policies in the high technology sectors can weaken the ability of U.S. firms to realize adequate returns in a variety of ways, e.g., signaling intentions in the marketplace not to permit U.S. firms to achieve adequate returns, ignoring or bypassing patent or copyright protection, and sometimes requiring know-how to be transferred as a condition of access to foreign markets. Thus, for U.S. firms engaged in research, the already high risk is amplified once a determined foreign competitor enters the field with government support.

Industrial development can be strongly influenced by a government's tax and expenditure policies. Many have industrial policies aimed at specific industries. The choice of policies is dependent on political, social and economic objectives.

Carried out with the necessary infrastructure of low-cost, readily available capital, a strong commitment to research and development, and abundant, highly trained personnel, foreign government industrial policies promoting indigenous development of selected high technology sectors can influence competitiveness.

Industry Targeting

Industry targeting -- the selective use of instruments by a government in order to enhance the competitiveness of a particular industrial sector -- is a concentrated form of industrial policy. The instruments can be combinations of fiscal and protective trade measures applied in varying degrees of intensity. In a number of instances governments also create or permit the formation of industry groupings which intensify their industry's concentration in order to achieve larger scale economies, reduce duplicative activities, or influence the direction of industry development. These groupings can simply be research cooperatives made up of major industry members and permitted by exceptions in antitrust laws, or they can be nationalization of the entire industry.

Industry targeting by the advanced developed countries has come to concentrate increasingly on the high technology sectors. A compilation of public statements about industries targeted by the governments of Japan, France and West Germany (Table 4.2) is essentially a list of high technology sectors. It should be noted that there are indications that other countries are beginning to adopt similar development strategies. For example, Mexico and Brazil have targeted the computer sector.

Table 4.2
Targeted Industries

	Japan	France	West Germany
COMPUTERS	X	X	X
MICROELECTRONICS	X	X	X
ELECTRONIC INSTRUMENTS	X		
LASERS	X		
OPTICAL COMMUNICATION	X		
ELECTRONIC OFFICE EQUIPMENT		X	X
BIOTECHNOLOGY	X	X	
ROBOTS	X	X	
ENERGY CONSERVATION EQUIPMENT		X	
UNDERWATER EXPLORATION EQUIPMENT		X	
AEROSPACE	X	X	
TELECOMMUNICATIONS	X	X	

Japanese Industrial Policy

The Japanese government has traditionally guided the development of Japan's manufacturing industries. Since the Meiji Restoration (1868) and even more rigidly since World War II, Japan has employed a wide array of programs aimed at actively targeting priority sectors and promoting industrial development and other social objectives. The policy instruments employed under these programs include financing for modernization, development, and investment; rationalization cartels; standards; supply-side tax incentives; and joint ventures. The power of Japanese industrial policy has been diluted somewhat in recent years, with the loss by the Ministry for Industrial Trade and Industry (MITI) of its direct control over foreign exchange and import licensing. Further, the growth of financing for industrial and sectoral development through the Fiscal Investment and Loan Program (FILP) has slowed considerably and its focus has been narrowed to the two ends of the spectrum -- high technology and declining industries.

For the last three decades Japan's industrial development has been led by a national industrial plan in one form or another. These plans have identified sectors the government considered to have the best prospects for technological advance and international competitiveness, such as steel, heavy machinery, autos, and petrochemicals, and measures were adopted to support their development. In the late 1950s, Japan shifted the emphasis of its industrial policy from merely improving individual company efficiency to concentrating its efforts on the development of priority sectors. For these sectors the government often restricted imports, prohibited foreign investment (except as minority partners), and encouraged imports of foreign technology. In the 1960s and 1970s, Japan encouraged greater specialization and economies of scale. In the early 1970s, emphasis shifted toward R&D assistance and sales of entire plants abroad, with a number of Japanese institutions working together to promote such efforts.

The Japanese government's current plan is laid out in the document entitled "Industrial Policy Vision of the 1980s," published by MITI in April 1980. This plan accords priority to energy related development and savings (particularly by rationalizing and modernizing production processes in small and medium sized enterprises), cutting Japanese external resource vulnerability, and expansion of high technology sectors.

The main financing organ for directly implementing Japanese industrial policy is the FILP, the Fiscal Investment and Loan Program. This is the so-called "second budget" which allocates about $100 billion annually. These funds are disbursed through the Japan Development Bank, the Small Business Finance Corporation, the Export-Import Bank, and other Japanese government institutions. The government also supports R&D to promote science and technology in its main budget.

The development of the high technology sectors is being accomplished largely through support of R&D activities, capital expenditures, and export expansion. Financial assistance is provided through the Japan Development Bank, MITI, and the Ministry of Finance. In addition, MITI supports directly through its own budget selected R&D projects and technologies. Participating companies share in the development work, in the know-how generated by the project, and in the rights to patents. (Over $51 million in direct subsidies in high technology are planned for 1982.)

Twelve so-called knowledge-intensive industries have been designated for emphasis in the 1980s, in addition to those already receiving aid. Information electronics is currently supported through substantial R&D subsidization -- such as the $400 million joint research effort by government and industry in microelectronics that began in the late 1970s, as well as by special assistance to software development.

The development of Japanese computer production is being aided, for example, by government supported sales of computers. The government is offering financial assistance and joint venture participation with private enterprise in leasing computers. The government also reserves about 90 percent of its own purchases for Japanese producers.

To aid development of telecommunications production, the Japanese monopoly Nippon Telephone and Telegraph Corporation (NTT) has long resisted opening its purchasing to bids from foreign suppliers. It has also directly supported the R&D of the major telecommunications equipment suppliers and has helped finance their exports.

In the 1950s, the bulk of FILP financing was directed at targeted priority areas; however, in recent years the major portion of FILP funds has been directed at less competitive, politically sensitive sectors such as small and medium sized companies and agriculture, or to social programs such as housing and regional development. Moreover, the growth rate in FILP has slowed in the last three years due to a slowdown in the growth of its funding base and administrative efforts to prune inefficient and wasteful expenditures from government operations. However, FILP funds remain very large and continues to grow. They are a key force in government direction of Japanese industry.

Included within the overall FILP budget is the budget of the Japan Development Bank (JDB) which is the organ tasked with extension of credit to the targeted areas. The JDB budget for 1981 was about $5 billion, of which about $2 billion was for energy-related promotion. About $600 million was earmarked for high technology areas. The JDB, has been making these loans at subsidized interest rates at a maximum of about 100 basis points below the long term prime rate. Outstanding loans for technology development amounted to $2 billion at the end of 1980. With informal "window guidance," targeted industries are insured of obtaining these incentive subsidies.

French Industrial Policy

French industrial policy has been highly selective, pragmatically shifting between market and nonmarket approaches to meet whatever pressures seemed to need countering. However, in the last year the French government has significantly increased its emphasis on policies targeted at high technology industries. The appointment of a cabinet-level Minister of Research and Technology (now Minister of Industry and Research), and commitment, by law, to increase public research spending by 17.8 percent annually until 1985 are evidence of the seriousness of French government efforts.

Before the mid-1970s, French industrial policy was aimed at preventing the takeover of French industry by foreign firms and at strengthening it through consolidation. It also strove to enhance French industry's ability to compete effectively with European firms, anticipating further European integration.

During the 1950s and early 1960s, the French government used a wide variety of techniques to stimulate industry, encompassing virtually all those used currently. For example:

- it selected certain sectors for encouragement, providing government education about R&D assistance;
- it encouraged mergers and consolidation;
- it created investment-banking facilities to provide risk capital;

- o it protected industry from international competition;
- o it deliberately exposed selected industries to international and domestic competition to force efficiency and competitiveness;
- o it allowed cartel-like groupings of industry to try to achieve international competitiveness; and
- o it encouraged specific sectors to cut their losses short when competitive forces were overwhelming.

The government directed its promotion efforts at high technology sectors, including nuclear energy, aircraft and space, energy conservation, electronic data processing, and telecommunications. It used a variety of techniques, including government purchasing, tax incentives and direct financial assistance, and special funds for distressed regions. In addition, it concentrated on stimulating consultation of companies with labor, strengthening the capital markets, and supporting R&D in key industries.

The planning structure for guiding a sector may be fairly simple or complex. In the case of the computer-related electronics industry, France has four separate plans: the Plans Calcul (completed in 1976) for the mainframe computer; the Plan Composants, for microelectronic components; the Plan Peripherique, for EDP peripheral equipment; the Plan Software; the Plan Electronique Civile; and the Plan Mechanique for the entire electronics and mechanics industries. In formulating these plans, the government works closely with industry.

A major feature of France's pre-1976 policy was that the criterion of success was achieving international competitiveness--preferably without, but if necessary with, technological assistance from abroad. It sought to promote high technology industries through government investment in "national champions" in various key projects and through the selective admittance of foreign firms that could accelerate technological innovation in cooperation with French companies. Once they have become concentrated, however, these "champions" have responded poorly to consolidation and competition.

The techniques had shifted somewhat from direct government guidance of specific sectors and firms, to greater reliance on market signals and enterprise strategy with stimulants to growing enterprises, so as to hasten market processes. These moves had brought French policy closer to both German and Japanese practice. But, the recent nationalization of several key high technology firms coupled with the 37 percent increase in the government R&D budget for 1982 places approximately three fourths of the national research effort under government control. In spite of government emphasis on following the "Japanese model," this increased government control of research may indicate return to more specific government guidance.

France and Japan have publicly announced the selection of target industries for future government support, and the lists are virtually identical (Table 4.2).

Examples of France's commitment to enhancing the competitive edge of targeted industries include the following policy actions:

- Tax deductions have been offered to people who purchase shares on the stock exchange, and mergers are being restricted.

- A five-year, five-billion franc support program for electronic data processing and telecommunications equipment is in place.

- The government has increased R&D spending by 33 percent, aiming to raise total spending from 1.8 percent of the GNP in 1980 to 2.5 percent by 1985.

West German Industrial Policy

Over the two decades preceding the first oil price shock, Germany was considered an economic "wonder". Government assistance played only a limited role in promoting this growth.

During the early 1970s, the government recognized that if German industry were to remain competitive internationally, it had to encourage greater investment in the dynamic, advanced, sophisticated industrial sectors as domestically produced, low value-added products were being displaced by imports from the developing countries.

- Through grants, low-cost loans, and tax concessions, the government increased its support to the high-technology sectors. For example, West Germany participated in European wide projects in nuclear energy and aerospace. By the late 1970s, the types of West German programs and techniques employed were not significantly different from those of France, though the extent of intervention in the economy was markedly less.

- A new science and technology ministry was created to provide federal R&D funding.

Since the late 1970s the government has been increasing its funding for R&D, especially in aerospace ventures in cooperation with other European countries and in the West German microelectronics industry. It helped finance firms buying data processing equipment and provided additional funds for R&D in energy-related projects. However, it has no official priority list of sectors to be supported. The government responds and guides, but it does not lead.

Costs of Industry Policies

Other governments have programs to promote their high technology industries, just as we have programs to promote space exploration. The success of these programs is not guaranteed. Substantial costs are incurred, for government support of specific industries requires steering resources away from other industries and guiding private sector decisions. These programs bear social and economic costs, including a reduction in economic choice. Moreover, for the United States the market would in most cases be more flexible and would adjust more quickly to technological developments than would government direction. Thus, if the government supports an unsuccessful project, it is likely to be more costly to the economy than a miscalculation by a firm. While R&D expenditures, a favorable tax climate and other such factors can create the potential for competitive success, we recognize that the key to effective competitiveness for the United States is sound business decisions.

Nonetheless, the industrial policies of foreign governments have substantial effects on the ability of U.S. industry to compete. The disruption of market signals and resulting resource flows caused by foreign industrial policies affect not only the domestic market of the country applying them, but international markets as well. By increasing concentration in and subsidizing investment in certain sectors, by raising or maintaining protective barriers, and through the application of various other tools of industrial policy governments can significantly alter the assessments U.S. firms make of the risk associated with an investment or reduce the potential market for a U.S. firm's product. In addition, industry policies can actually take away customers for U.S. products.

TRANSFER OF TECHNOLOGY

The transfer of U.S. technology by the private sector has helped foreign industry approach or equal the technological sophistication of the United States. This has been particularly true in the case of Japan. Avenues for the transfer of technology also exist through the weapons-related international cooperative programs of the Department of Defense. As other countries have made significant strides in high technology fields, the reverse flow of technology has become important.

The Transfer of U.S. Civilian Technology

Transfer of technology from the United States to foreign economic activities could be in a form essentially noncompetitive with activities in the United States, and further, could complement U.S. activities. In such cases these transfers would benefit the importing country, the firms or individuals exporting them, and the U.S. economy at large. Increased productivity and income would accrue to the importing country, royalty receipts would be received by the exporters, and the U.S. economy at large would gain via increased foreign exchange earnings, perhaps increased export demand, and complementary production arrangements.

Alternatively, transfers of technology could occur -- and undoubtedly have in the past -- in areas which are usable in activities directly competitive with activities within the United States. In such cases foreign countries benefit, the firms benefit via royalties, but the U.S. economy or the industry at large may not be net beneficiaries.

A net loss might occur for the United States because the transferred technology could significantly increase the strength of a competitor which would subsequently reduce U.S. advantage either in the foreign market or in the domestic U.S. market itself. In such a case the individual returns of the seller of the technology might not be as great as the overall cost of the competitive loss for the country.

The potential loss from civilian technology transfer would tend to be reduced by two factors:

- First, to the degree that the domestic U.S. economic environment is (1) attractive to new production facilities incorporating the technology, (2) provides adequate incentives returns to the investor, (3) has competitive capital costs, and (4) ensures a stable, growing domestic economy, then the transfer of technology to foreign economies would be reduced.

- Second, the effects over time of technology transfers will be more beneficial if technology can be as readily obtained by the United States as transfered from the United States.

The assumption of free transfer of knowledge both ways is generally made in arguments for increased information and technology flow between economies, but this has not universally been the case.

Japanese Technology Transfer Policies

In contrast to other U.S. competitors, Japan has implemented specific technology transfer policies aimed at improving its international competitiveness. These polices were not, moreover, isolated instances of government intervention targeted specifically at Japan's international technnology transactions. They formed an integral part of Japan's national industrial policy.

After World War II, Japan instituted a national control system over technology transfers, based on the Foreign Exchange and Foreign Trade Control Law of 1949 and the Law Concerning Foreign Investment of 1950. All technology transfer contracts and direct foreign investment projects had to be screened and approved by the Japanese government. The government believed that without its direct control, Japanese industry might fall under the domination of foreign interests. This concern dated back to the initial industrialization effort of the post-Meiji Restoration.

The government sought to exert a countervailing power on behalf of Japanese firms vis-a-vis their foreign competitors, who had superior technologies. It also discouraged competition among rival Japanese firms in their efforts to gain access to foreign technology. This, too, was intended to strengthen the bargaining position of Japanese technology purchasers. The government encouraged "staggered, orderly entry" by individual firms into specific industries, allowing the initial entrants to establish temporary monopolies based on imported technologies. In another effort to improve their access to technology, Japanese companies expanded foreign investment in research-intensive countries, such as the United States and West Germany.

Imported technology has contributed to Japan's exceptional economic growth, but it was only part of an overall strategy.

- In recent years, imported technologies have become a complement rather than a substitute for domestic R&D and innovations.

- In the 1970s, Japan put greater emphasis on importing technologies that had not yet been commercially exploited in the transferring countries themselves.

- In the past, Japan's domestic R&D efforts were geared primarily toward modifying, adapting, and improving imported technologies. Now, however, it is targeted at the high-risk stage or areas with the potential for major technological advances.

Department of Defense Technology Transfers

Transfers of technology take place through various Department of Defense programs operating within the framework of NATO and U.S. relations with Japan, Korea, Israel and other allies. These programs were originally designed to enhance U.S. interests by strengthening the military power and defense-related industrial capacity of U.S. allies. They continue in pursuit of U.S. military, political and economic aims with arms standardization (inter-operability) remaining as a prime objective. With the increased ability of European and Japanese industry to apply technological advances, our allies are now able to contribute a more equitable share of NATO's defense. This consequently, alleviates the previous overburden of the U.S. Share.

Coproduction

In Department of Defense programs, technology transfers take place largely through the avenues of coproduction. These programs seek to reduce the development and production cost of weapons system by avoiding duplication of resources, and to promote technically advanced, industrially productive, and economically viable defense industries of U.S. allies.

Technology transfer under these programs is a major defense-related issue. Coproduction has been important in integrating and strengthening the defense-related industrial base of U.S. allies, and the United States has benefited from technology transferred from its allies. But, on balance, U.S. allies have been the greater beneficiaries from these transfers because of the more advanced level of U.S. military technology.

Coproduction has had an adverse commercial effect for the United States in a number of cases.

Defense-related Offsets

Another important defense-related instrument of technology transfer from the United States to its allies has been the demands of foreign arms purchasers for "offsets". Offsets are related to the balance of payments and jobs in connection with arms sales. They commit the seller to "offset" the impact of the purchase on the buyer by applying a certain percentage of the purchase price to purchases from, or work in, the buyer nations. In recent years, offsets have become a certain favorable condition, other than the price, that the buyer extracts in connection with a purchase. In most cases, the size of the offset is a primary factor in a nation's decision to buy a specific weapons system from competing industries.

The practice of offsets has become intricately intertwined with the various activities conducted under the coproduction programs. Technology transfer, in various forms, plays a part in offset.

V. FOLLOW-ON TO CABINET COUNCIL ON COMMERCE AND TRADE

The Cabinet Council on Commerce and Trade recognizes the importance attached to continuing U.S. preeminence in high technology for our economic and national security interests.

The evidence developed by the CCCT directed study of the competitive posture of the United States in high technology suggests that the era of U.S. dominance has past. This is not surprising given the abnormal postwar gap which emerged between the United States and other advanced countries. It was inevitable that it would narrow.

The CCCT report raises a number of questions regarding the future of U.S. high technology. These issues divide into those specific to particular high technology sectors and those which cut across most, if not all high technology sectors. The CCCT has directed that a follow-on work program explore these issues and develop, if appropriate, recommendations.

In order to accomplish the CCCT mandate, a two pronged work program has been developed. The first element examines specific competitive factors in the following sectors: computers; telecommunications; microelectronics; aircraft; robotics; biotechnology; and new composite materials.

For each of these sectors an in-depth analysis will be performed of the competitive factors at work in order to provide the basis for assessing the economic and national security implications.

The second element of the work program examines a number of broader factors which are especially relevant to competitiveness in high technology. These include: an examination of U.S. competition policy as it affects U.S. firms in the area of cooperative research; a review of tax treatment of research and short-lived assets; an examination of the foreign sponsored target industry programs usually designed to promote selected high technology sectors; an assessment of how the increasing technological capabilities in foreign industries affect U.S. national security interests; and structural questions regarding the U.S. labor force.

NOTE 1: <u>Exchange Rate Effects</u>

The United States allows the market to set exchange rates. There are no exchange rate objectives. Underlying changes in demand and supply act to determine exchange rates. That is, the exchange rate is endogenous determined.

Changes in exchange rates affect the measurement of a trade share -- that is, the ratio of a country's exports to other countries' exports -- in two ways:

<u>First</u>, there is an immediate accounting effect. U.S. exports, for instance, are usually compared with the sum of other country exports <u>which are expressed in U.S. dollar terms</u>. If the dollar depreciates in value, then those exports of other countries -- when converted into dollars -- will be given a greater value. Automatically, therefore, <u>the U.S. share will decline</u>, without anything else happening.

Second, an exchange rate change can act to increase or decrease the volume of exports by altering the amount of demand for a product much as any price change would. In the example of a dollar depreciation, there would tend to be increased demand for U.S. exports, because the price to foreign buyers now could be lower. Over time, therefore, the U.S. export share would increase due to this.

How much increase would occur versus the initial share decrease would depend on the price responsiveness (or price elasticity) of demand for the product. Depending on the price responsiveness, a currency depreciation could eventually either lower or raise a country's export share compared to its original level.

NOTE 2: Comparing Changes in Shares

In comparing changes in export shares over the short run --say from quarter to quarter, or even over a period of one or two years -- an explicit consideration of how exchange rate changes have affected the share calculation is highly appropriate.

Comparing the behavior of shares over a several year period, though, is a different matter. After several years -- certainly after as long as a decade -- the changes in demand that will result from a currency realignment will have been completed. Then what is precisely wanted for a longer-term comparison is the share calculated using goods as actually valued by the international marketplace -- that is, by the exchange rates which actually existed at the beginning and at the end of the period.

The fact is, of course, that the U.S. dollar depreciated in the 1970s. While in the short-term this acted to increase the value of other countries' high technology exports versus those of the United Stated -- and thus to decrease the U.S. export share -- it also made the U.S. products more attractive in price relative to competitors. This acted to help increase the international demand for U.S. high technology products.

In comparing the performance of U.S. high technology exports at the start versus the end of the decade what we are really interested in is the final result of these two effects: how much did we once sell versus foreign competitors, and -- after relative price changes have had time to work themselves out into new buying patterns -- how much do we sell now? This long-term comparison requires that we use the exchange rates that actually prevailed.

Alternative calculations can be made holding exchange rates constant at some value and then calculating what a specific product's share would have been at the constant rates. This exercise can be useful in short-term, quarter to quarter assessments when the assumption can be made that there was no change in price-induced demand for exports. Over a longer-term, though, pretending exchange rate changes did not occur also pretends that corresponding changes in the demand for the product did not occur. Demand changes did occur, of course, and cannot be ignored in this way.

Figure 2.1
GROWTH OF REAL OUTPUT
(1970 - 1980)

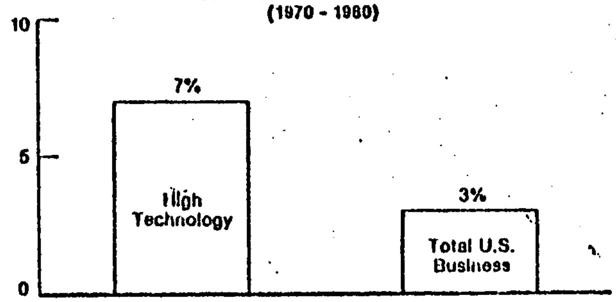


Figure 2.2
RATE OF INFLATION
(Average annual increase)

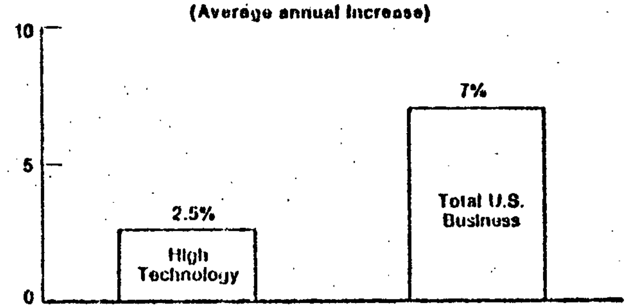


Figure 2.3
TRADE BALANCE IN 1980
(Billions of Dollars)

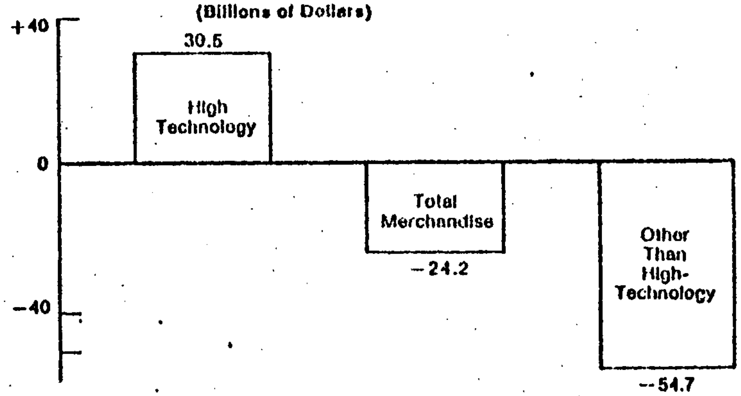
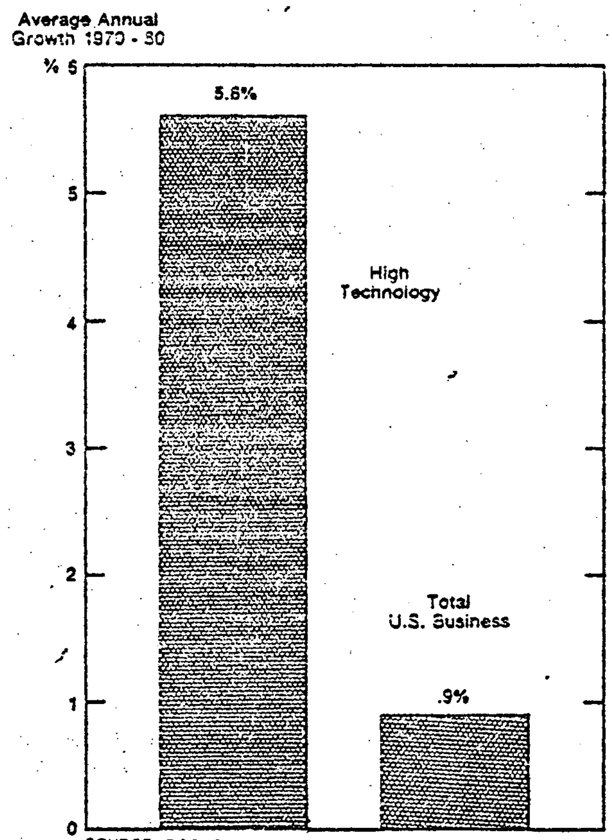


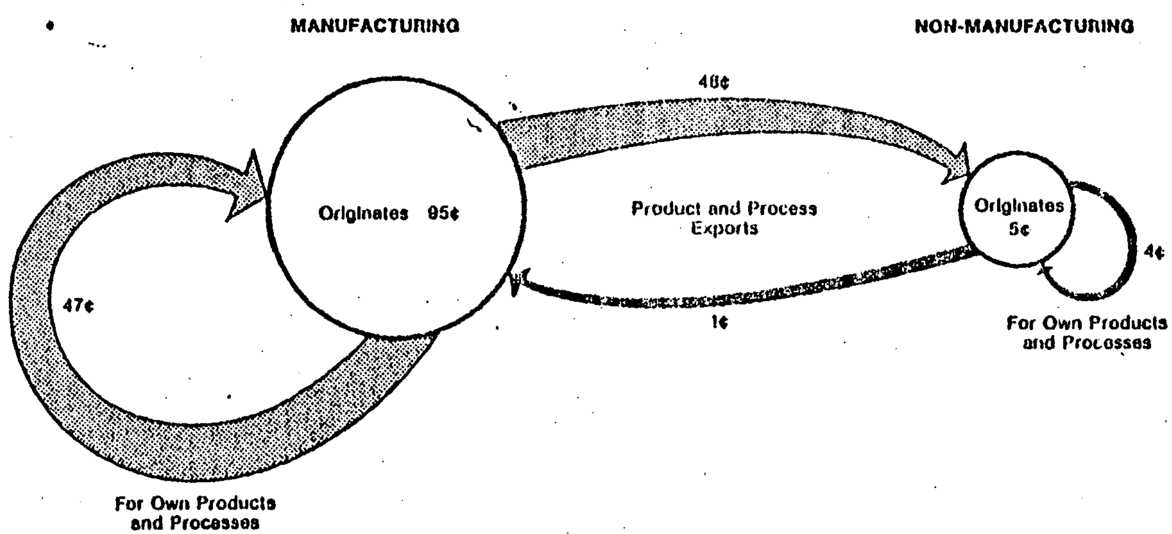
Figure 2.4
PRODUCTIVITY GROWTH IN
HIGH TECHNOLOGY INDUSTRIES



SOURCE: DOC/ITA

Figure 2.5

FLOWS BETWEEN MANUFACTURING AND NON-MANUFACTURING SECTORS PER DOLLAR OF TOTAL R&D EXPENDITURE



Source: F. M. Scherer; "Research and Development, Patenting, and the Micro-Structure of Productivity Growth;" Report to NSF, June 1981.

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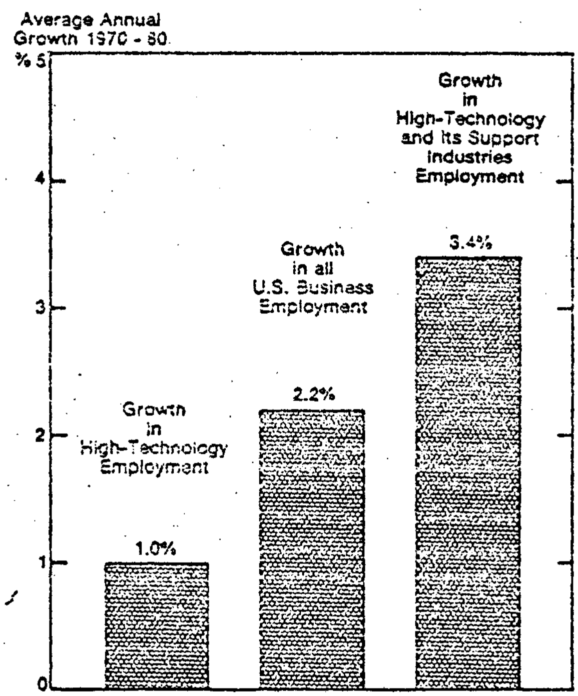
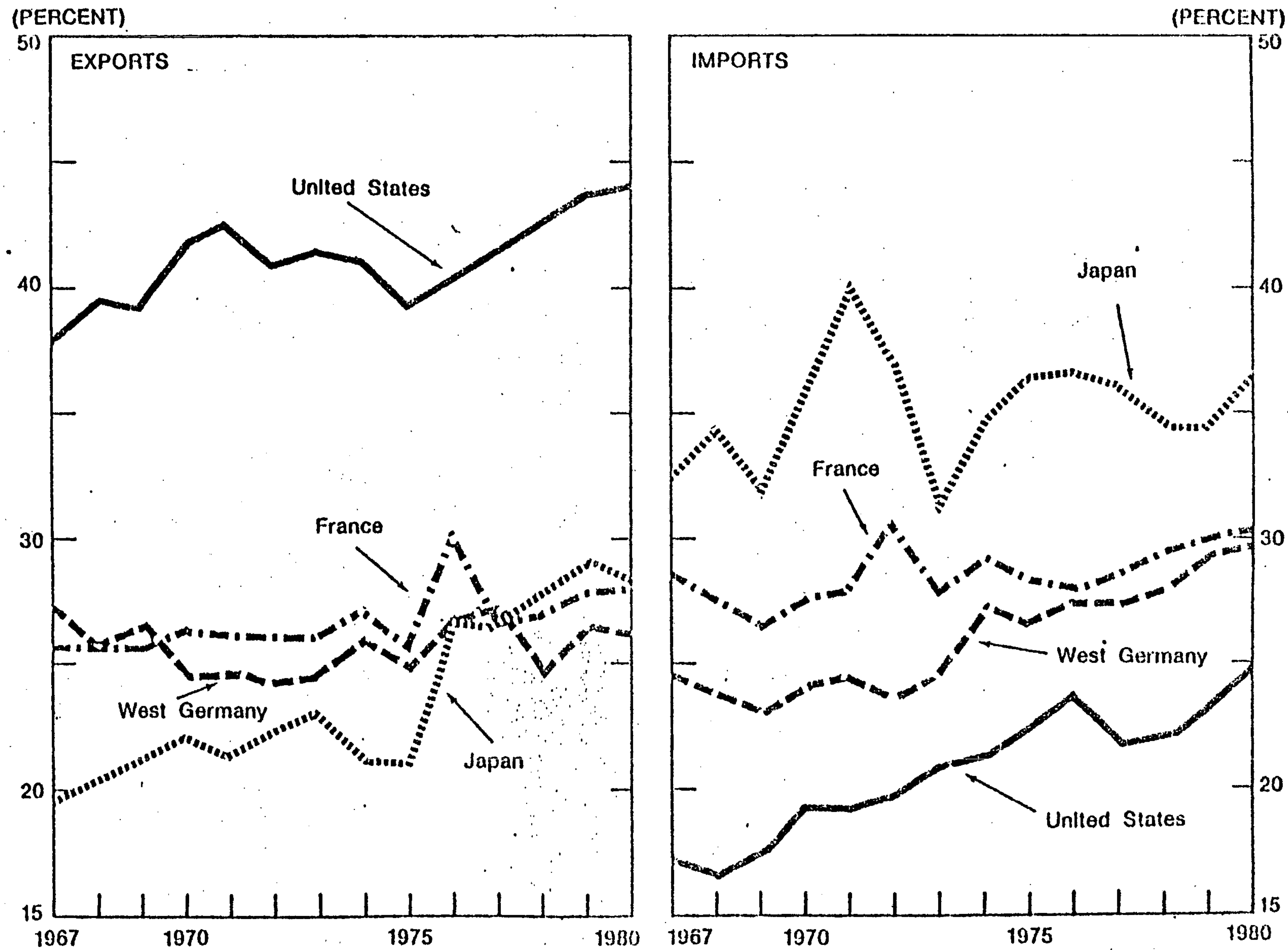
Figure 2.5
EMPLOYMENT GROWTH IN
HIGH TECHNOLOGY AND
SUPPORT INDUSTRIES



SOURCE: DOC/ITA From BLS Data.

Figure 2.7

PROPORTION OF TRADE REPRESENTED BY HIGH TECHNOLOGY PRODUCTS



Source: DOC/ITA

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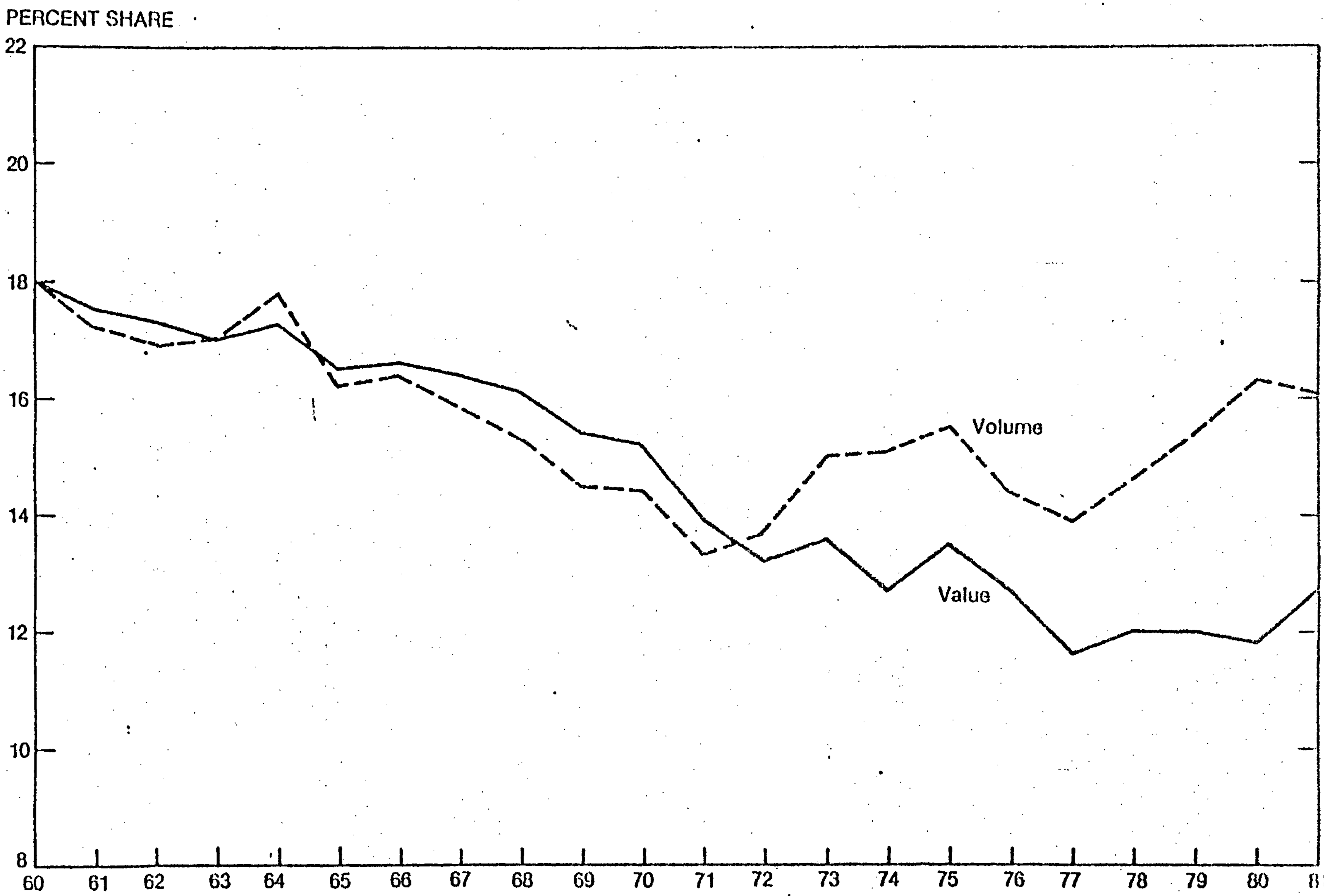
Figure 3.1
U.S. SHARE OF EXPORTS TO THE WORLD
(Volume share in 1960 U.S. dollars)



Source: International Monetary Fund, International Financial Statistics

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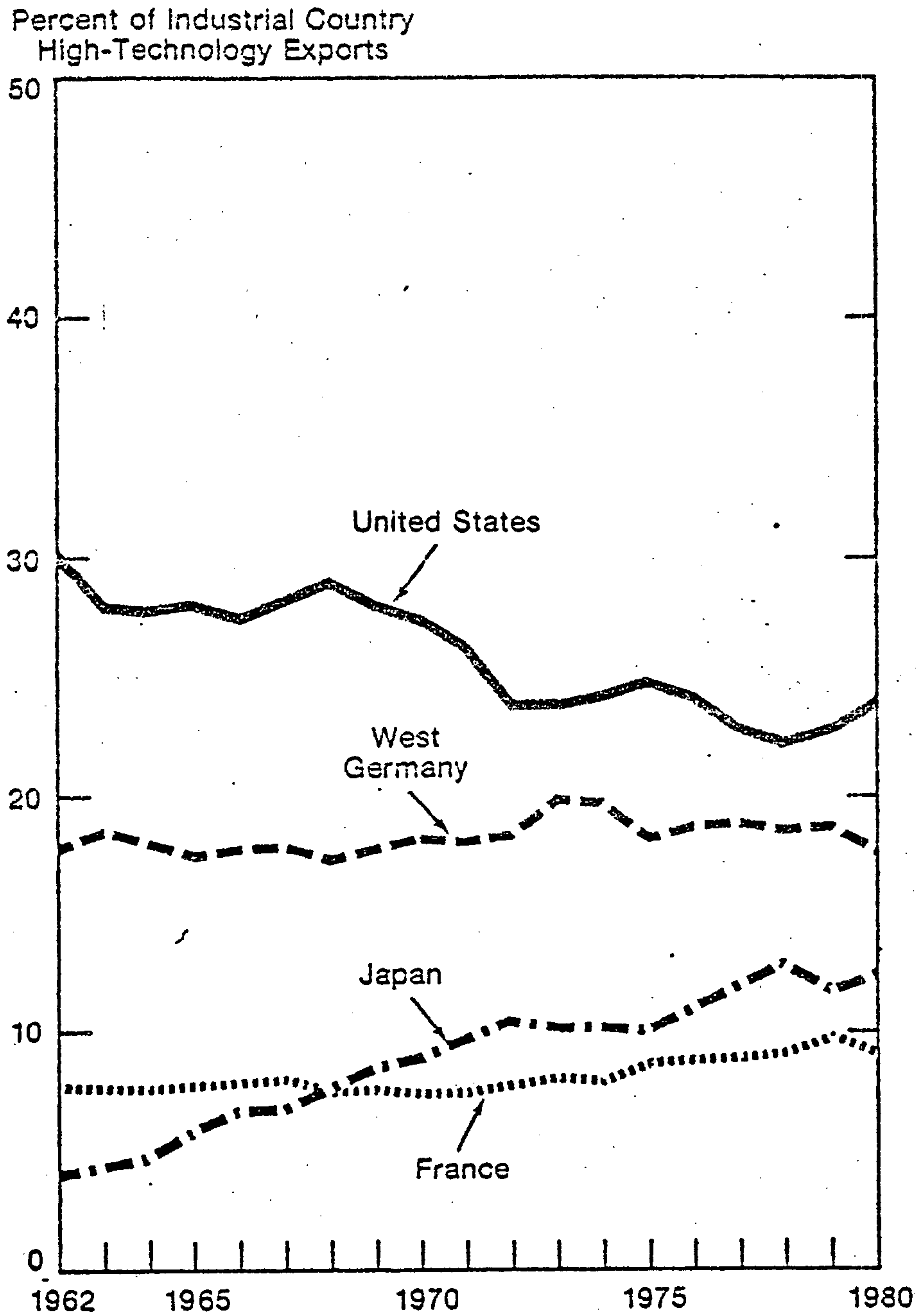
Figure 3.2

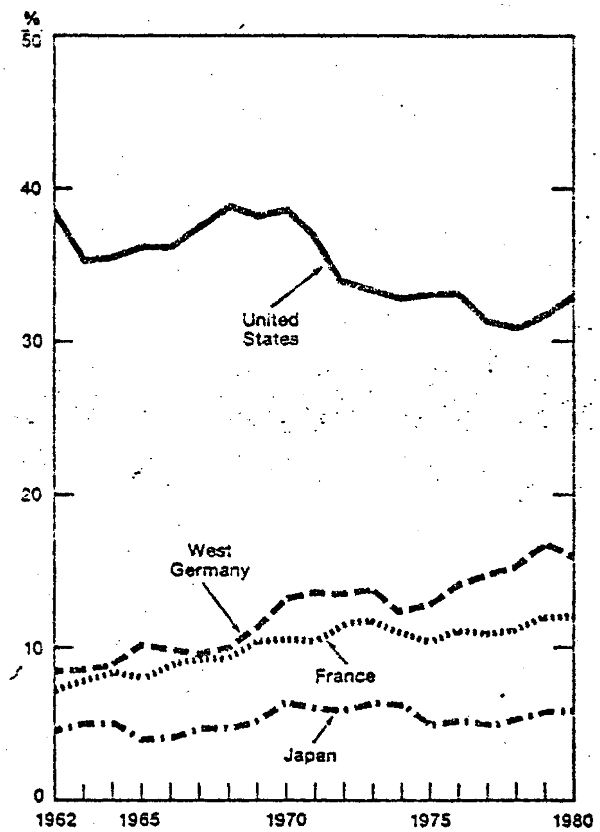
SHARES OF MAJOR INDUSTRIAL COUNTRY HIGH TECHNOLOGY EXPORTS



Source: DOC/ITA from UN Series D Trade Data.

The industrial countries are: Austria, Belgium, Canada, Denmark, France, Italy, Japan, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom, United States, and West Germany.

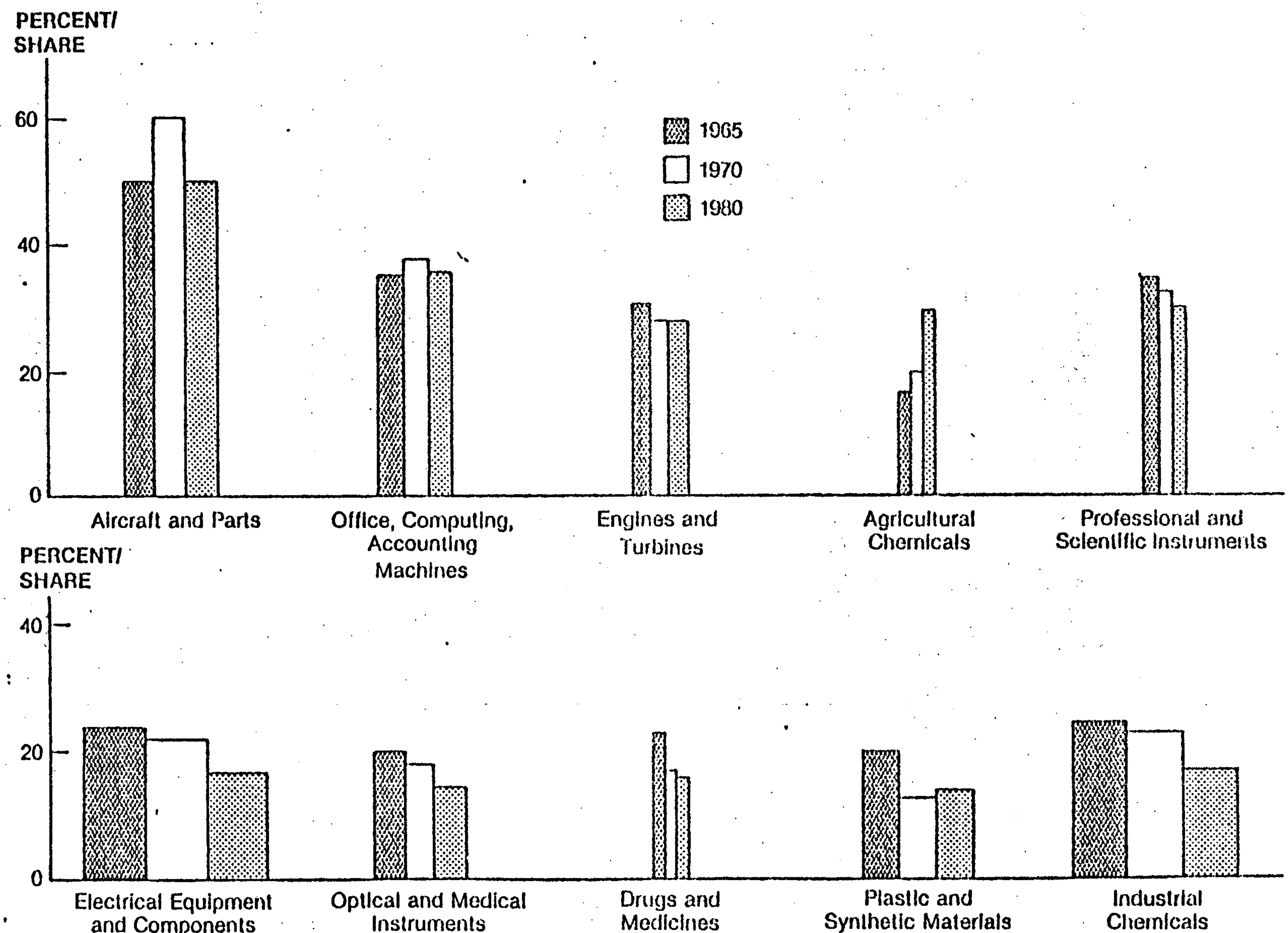
Figure 3.3
SHARES OF THIRD COUNTRY
HIGH TECHNOLOGY IMPORTS



Source: DOC/ITA from UN Series D Trade Data.

Figure 3.4

U.S. Shares of World High Technology Exports



Source: UN Series D Trade DATA.

Note: The World is defined as fifteen major industrial countries—Austria, Belgium, Canada, Denmark, France, West Germany, Italy, Japan, Luxembourg, Netherlands, Norway, Swe[illegible], Switzerland, United Kingdom, and United States.

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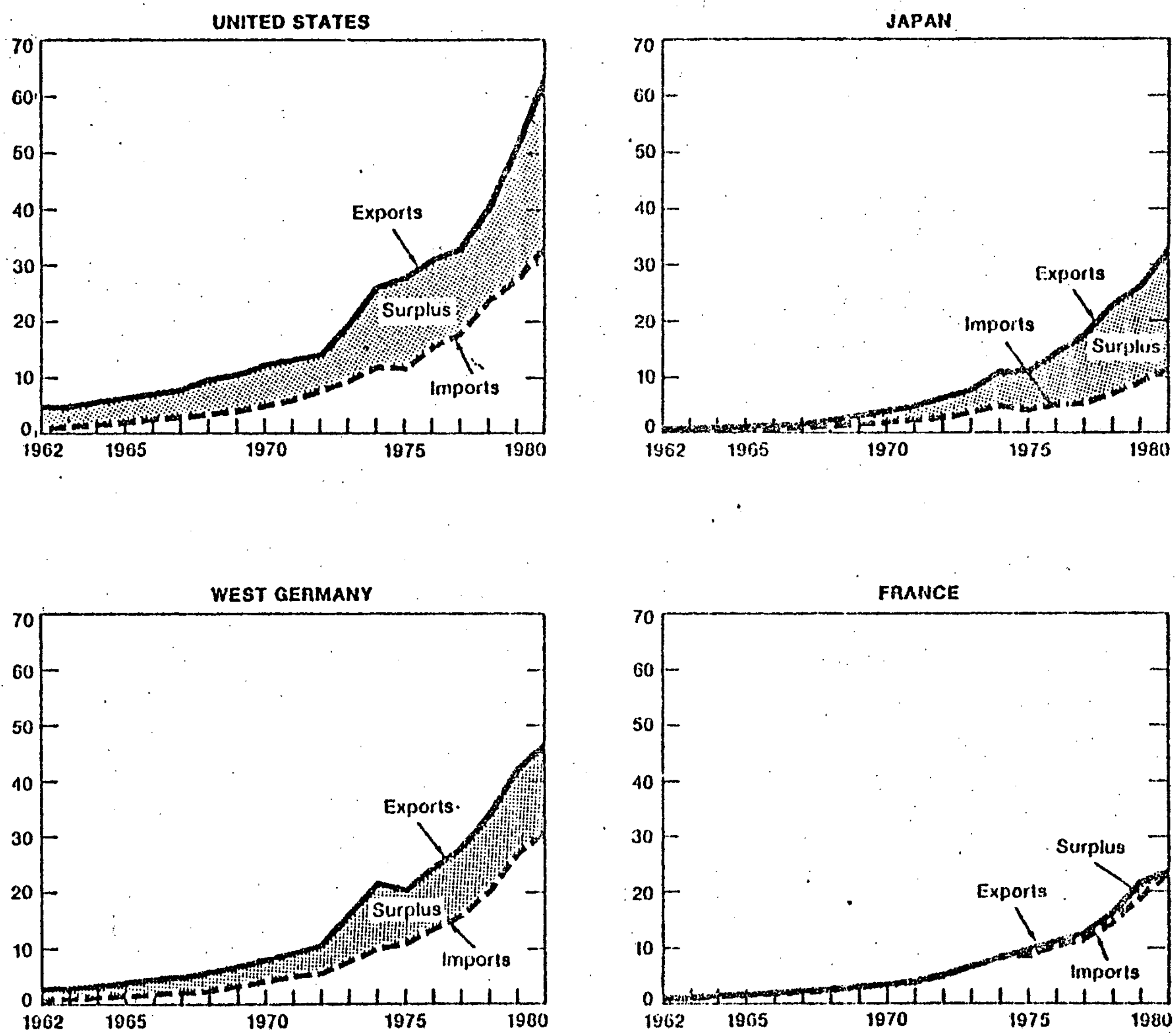
Figure 3.5

TRADE WITH THE WORLD IN HIGH TECHNOLOGY' PRODUCTS 1962 - 1980
(In Billions of U.S. Dollars)



'Note: The definition of high technology used here is the DOC2 definition excluding radio and TV receivers.

Source; ITA/DOC from U.N. Series D Trade Data.

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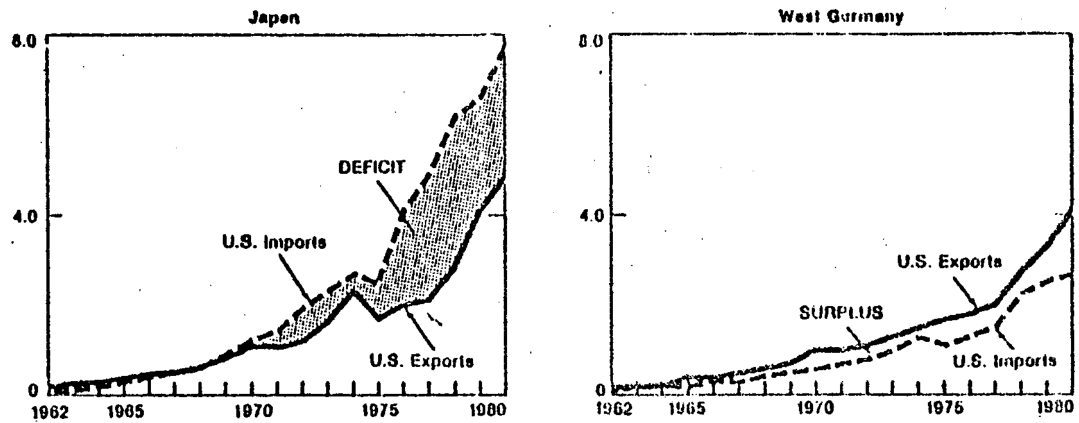
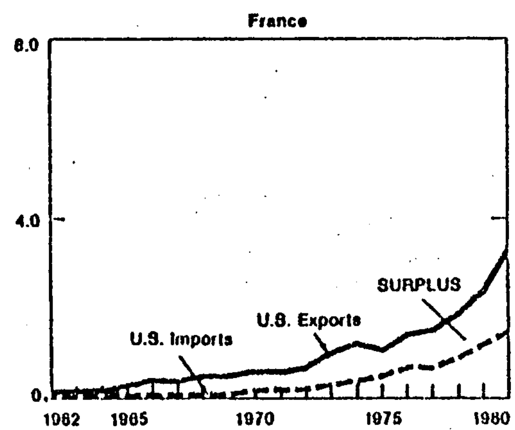
Figure 3.8

U.S. BILATERAL TRADE IN HIGH TECHNOLOGY[1] PRODUCTS 1962 - 1980
(In Billions of U.S. Dollars)





[1]Note. The definition of high technology products used is the DOC2 definition excluding radio and TV receivers.

Source: DOC/ITA from UN Series D Trade Data.

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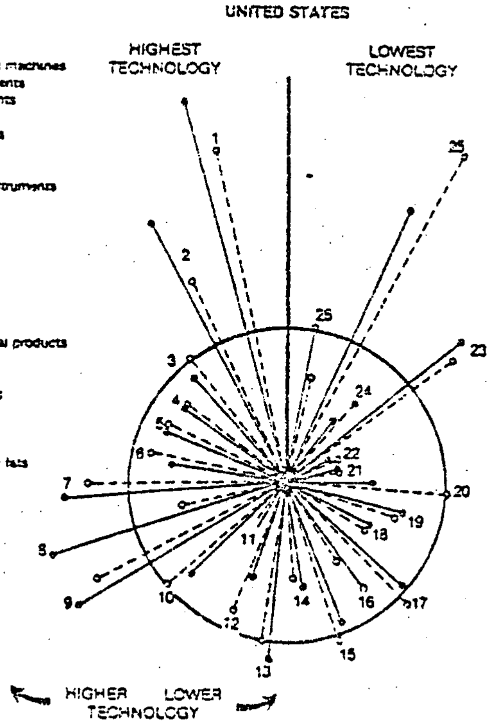
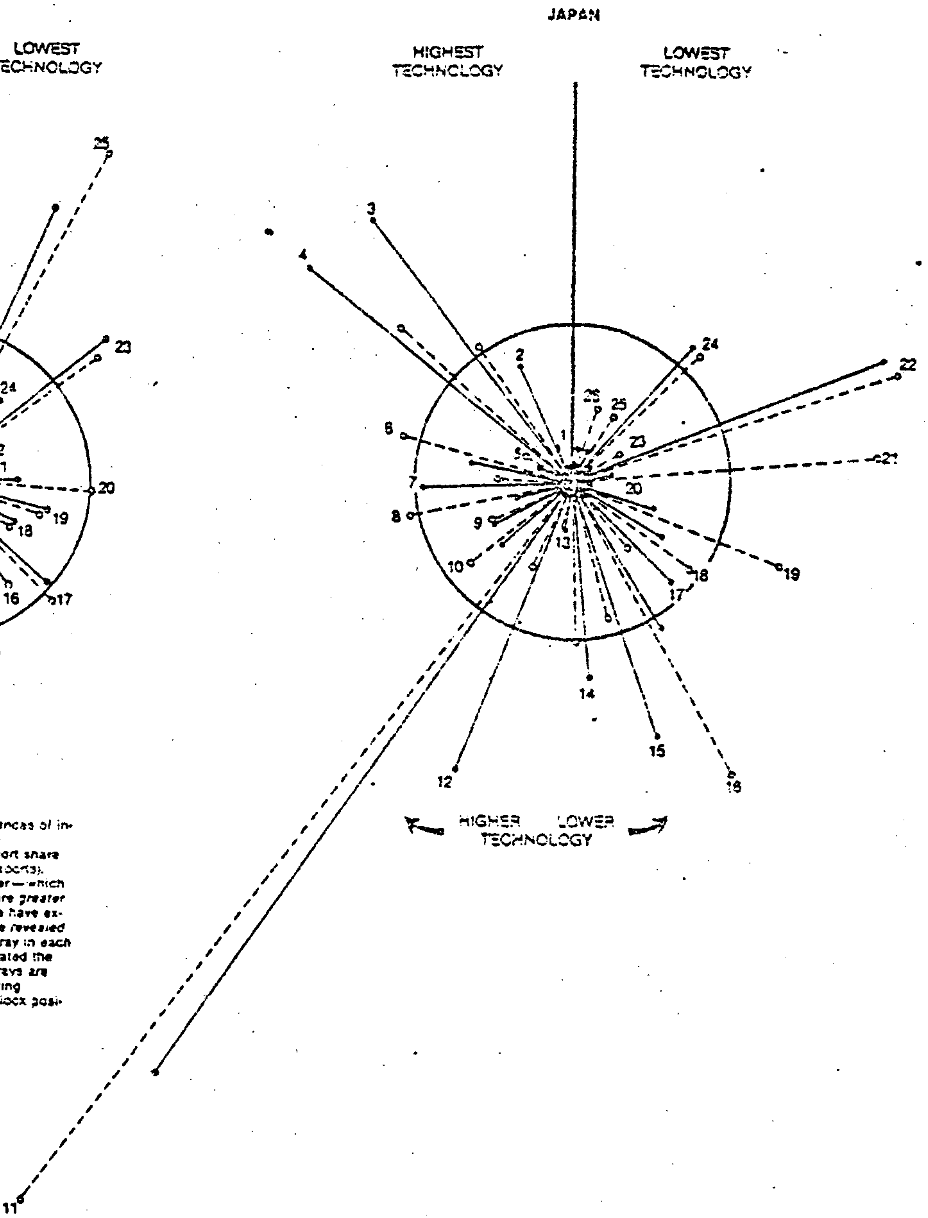
Figure 3.7
REVEALED COMPARATIVE ADVANTAGE IN 1965 AND 1980

INDUSTRY
1: Aircraft and parts
2: Office, computing, accounting machines
3: Electrical equipment, components
4: Optical and medical instruments
5: Drugs and medicines
6: Plastic and synthetic materials
7: Engines and turbines
8: Agricultural chemicals
9: Professional and scientific instruments
10: Industrial chemicals
11: Radio and TV receiving eqpt
12: Road motor vehicles
13: Other chemicals
14: Electrical machinery
15: Other transportation eqpt
16: Textile fibers, yarns, fabrics
17: Non-electrical machinery
18: Non-ferrous metals, misc metal products
19: Misc manufactured products
20: Fuels
21: Apparel, footwear, accessories
22: Iron and steel
23: Foods, beverages, tobacco
24: Leather and rubber products
25: Animal and vegetable oils and fats
26: Wood and paper products

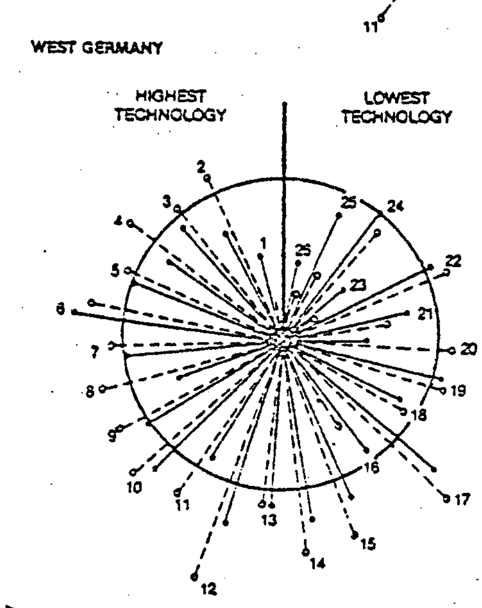




NOTE: These diagrams indicate the export performances of industries relative to other industries *within the same country*. The circle represents the average world export share for the country (i.e. total exports divided by world exports). Individual industries—shown as rays from the center—which extend beyond the circle have an export market share *greater* than average for the country. Those inside the circle have export shares *less* than the country average. These are *revealed comparative advantage measures*, with the longest ray in each country indicating the industry which has demonstrated the greatest relative advantage for that country. These rays are positioned in order of technology—intensity, mounting clockwise to the greatest intensity at the twelve o'clock position.

Source: ITA/DOC from U.N. Series D Trade Data

LEGEND:
Dashed Lines = 1965
Solid Lines = 1980



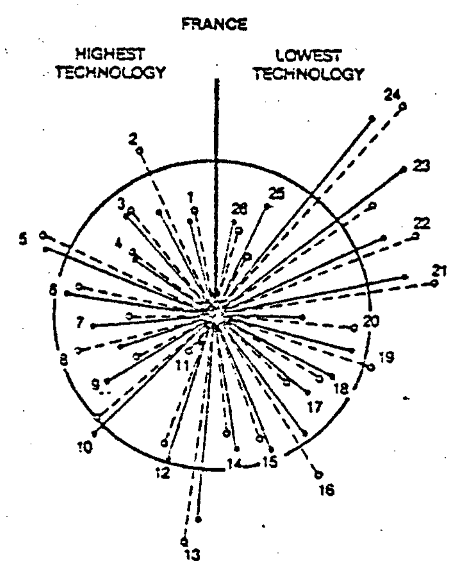
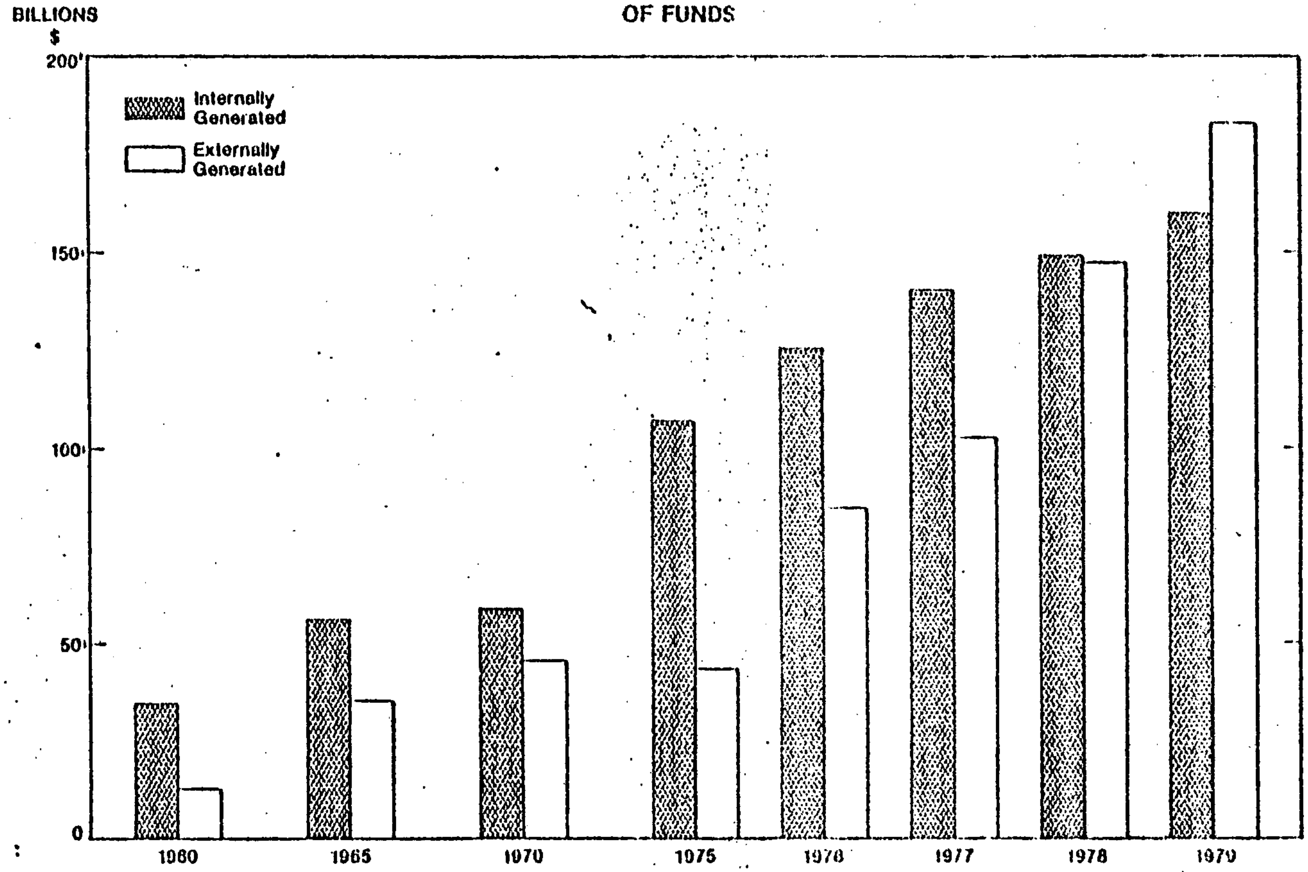


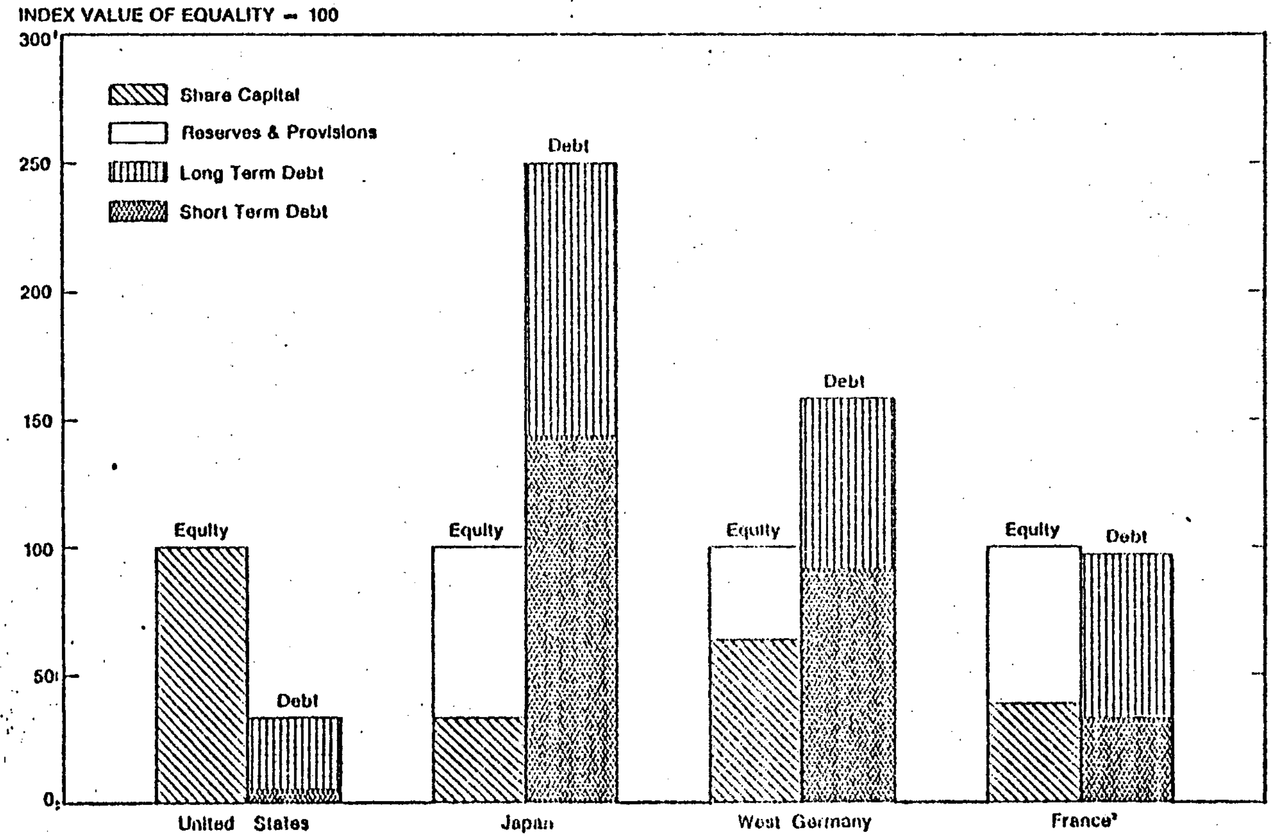
Figure 4.1
U.S. CORPORATIONS' SOURCES OF FUNDS



[1]Internal sources include: Undistributed profits, Adjustments, and Capital consumption allowances. External sources are defined as net increases in corporate liabilities.

Source: Statistical Abstract of the United States, 1980; Table No. 945.

Figure 4.2
COMPOSITION OF CORPORATE LIABILITIES



Composition of Corporate[1] Liabilities in 1979. Value of Equity Holdings = 100.

[1]Manufacturing sector for Japan & West Germany; French industry; all non-financial institutions in the United States.
[2]French data for 1978.

Figure 4.3
SELECTED INDICATORS OF R&D FUNDING
FOR THE UNITED STATES, JAPAN, WEST GERMANY,
AND FRANCE

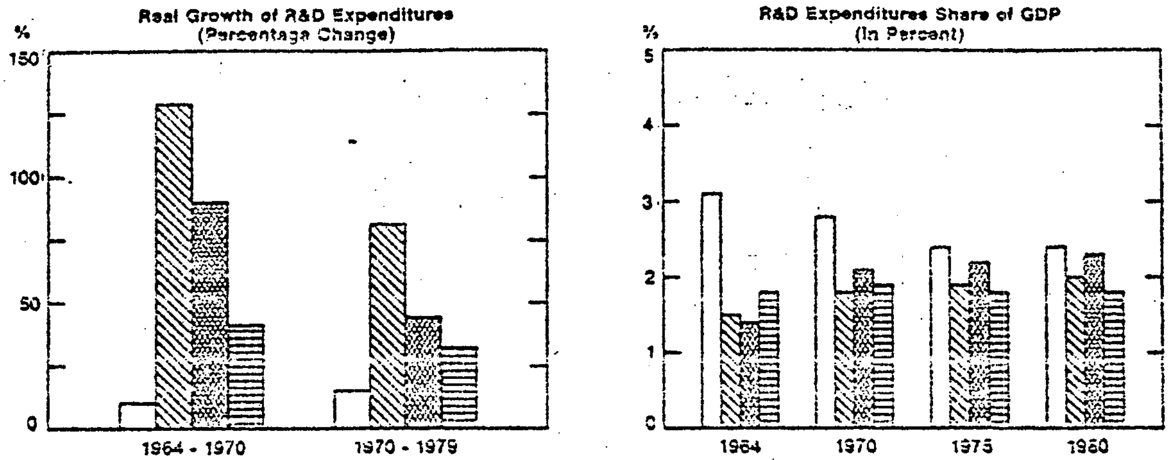


Figure 4.4

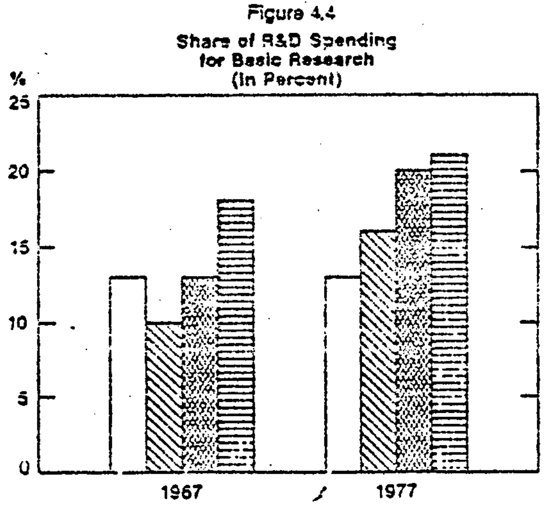


Figure 4.5

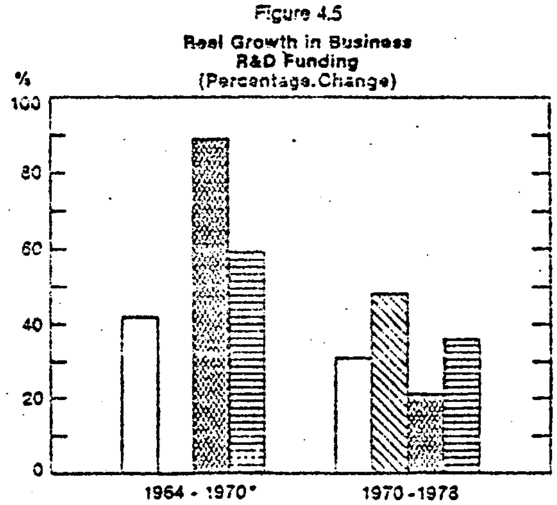
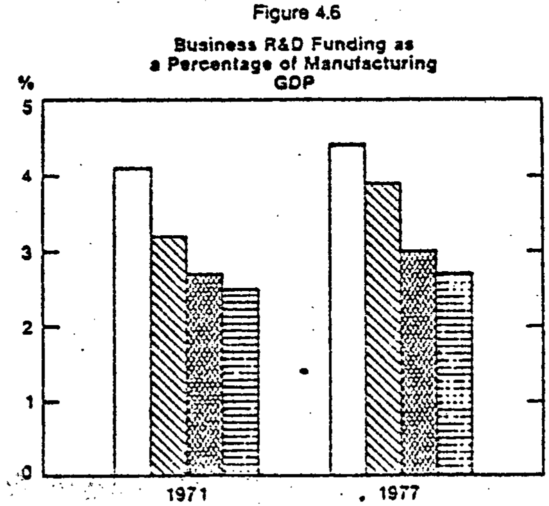


Figure 4.6



LEGEND:

United States

Japan

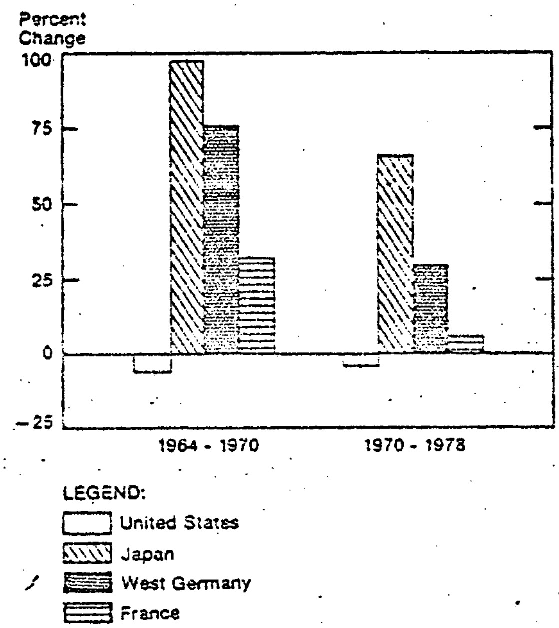
West Germany

France

*Data not available for Japan.

Source: OECD, Science and Technology Indicators Unit.

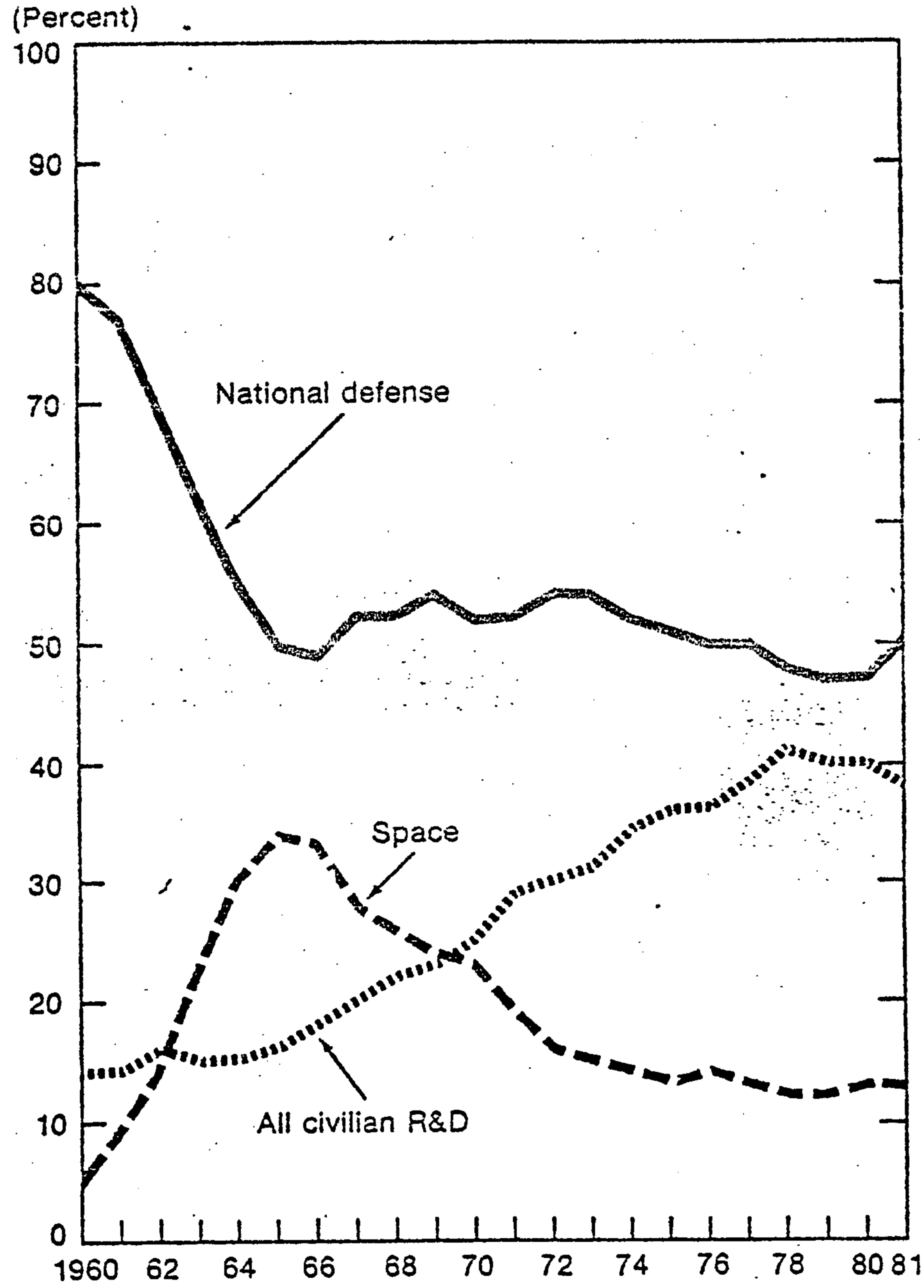
Figure 4.7
REAL EXPENDITURES BY
GOVERNMENT ON R&D



Source: OECD, Science and Technology Indicators Unit.

Figure 4.8

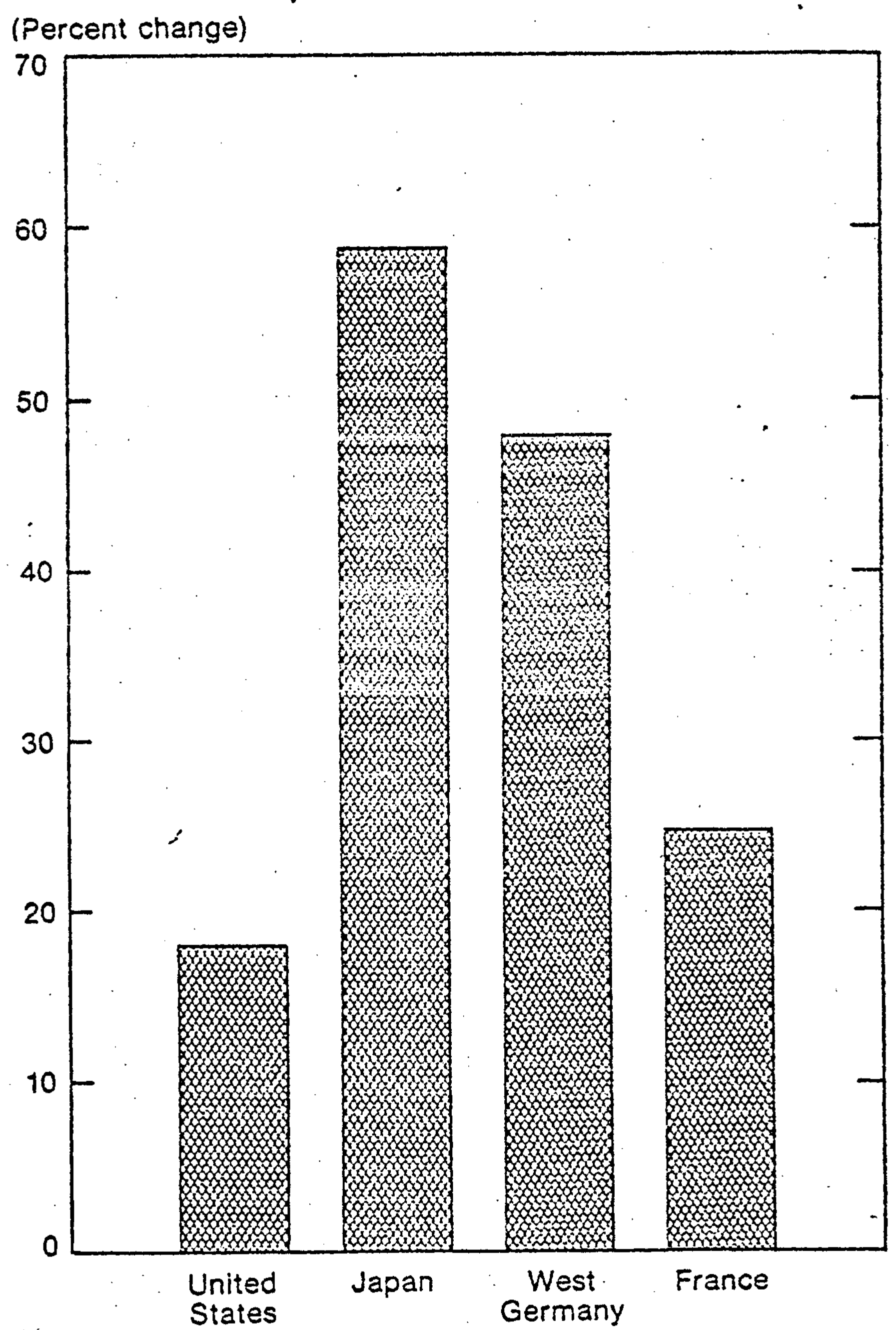
U.S. GOVERNMENT OBLIGATIONS FOR R&D BY MAJOR BUDGET FUNCTION



Note: Estimates are shown for 1980 and 1981.

Source: NSF, Science Indicators—1980.

Figure 4.9
GROWTH IN SCIENTIFIC AND ENGINEERING PERSONNEL, 1970-1979
(Percent Change)



REVISED DRAFT

APPENDICES TO

AN ASSESSMENT OF U.S. COMPETITIVENESS IN

HIGH TECHNOLOGY INDUSTRIES

September 8, 1982

APPENDIX A

DEFINING TECHNOLOGY-INTENSIVE TRADE

OVERVIEW

The technology-intensive component of trade has been an extremely difficult concept to measure quantitatively. Nevertheless, three techniques have been developed to define technology intensive trade, all of which have contributed to the analysis of the U.S. competitive situation. This report has attempted to avoid entering a debate concerning the best identification technique, while remaining aware of the problems associated with each. The purpose of the report is to assess the competitive situation of both products and industries which have been shown as technology intensive by all methods. In addition, since the report takes both a product and an industry perspective it was necessary to use several of the identification methods to acquire a complete picture of the competitive situation. Finally, as the data in the statistical appendix illustrate, the general trend of declining U.S. competitiveness is shown to exist using any of the definitions of technology intensity.

No single definition of high technology trade has been shown to be the best or most definitive for several reasons. The question of what can be considered the best proxy for technology intensity has yet to be resolved: R&D expenditures, and scientists and engineers in the workforce are only proxies for technology intensity. Additionally, even at their most disaggregated level, product data frequently contain both technology-intensive and non-technology intensive goods. The very nature of technological change, also, precludes a final definition of specific goods or industries as high technology, as the situation is constantly changing.

The definition of what constitutes technology-intensive trade has been a subject of controversy since the mid 1970s. The search for an appropriate U.S. policy concerning international technology transactions, which has continued since the late 1960s, served as the impetus for several studies concerning the effects of technology on trade. These studies have developed three techniques for identifying technology intensive activities and have been the source of debate concerning which method presents the best measure of technology intensive trade. Two have identified technology-intensive trade on a product basis and one has identified it on an industry basis.

It should be noted that the R&D data available requires that industries or products must be considered at a fairly aggregated level. Consequently, some specific sub-industries which are really of a fairly low technology intensity are included in the definition. Also, some specific high technology industries are excluded. Detailed industry examinations -- such as those discussed in Appendix C -- should, though, consider specific high technology industries (for instance, robotics and computer-related machine tools) which are excluded from the aggregate definitions made for trade data purposes.

INDUSTRY BASED DEFINITION

M. Boretsky (1974, 1982) developed an industry-based definition (DOC1) of technology-intensive trade. Boretsky used industry R&D expenditures as a percentage of industry value added, and industry employment of scientists, engineers and technicians as a proportion of the industry workforce to determine which industries were technology-intensive and a sub-group which were considered high technology. Since he used an industry basis, the definition did not differentiate between the technology-intensive and non-technology intensive products within each industrial sector.
Industries generally produce a wide range of products which will fall in both the technology-intensive and the non-technology intensive categories. In spite of this, the Boretsky definition has been useful in identifying which industries can be considered to be high technology industries.

PRODUCT BASED DEFINITIONS

In order to account for the wide range of products produced by any one industry, R. Kelly (1974, 1977) developed an index of technology-intensity on a product rather than industry basis. Kelly used applied R&D expenditures by product field and the value of product shipments to devise intensity ratios. After the products were ranked by their "intensity," they were then divided into technology classifications. Kelly, somewhat arbitrarily, selected the first quartile of R&D intensities as high technology goods (1974), but later defined product groups with above average R&D intensities (DOC2) as technology intensive.

Aho and Rosen (1980) essentially used Kelly's technique to determine which product groups were technology-intensive. They used more recent R&D expenditures data and shipments data on a product line basis to develop an intensity index. After ranking the product groups by intensity, they also identified product groups with above average intensities as high technology products. In order to facilitate international comparisons, Aho and Rosen concorded the U.S. data with trade data classified according to the Standard International Trade Classification (SITC). The concordance was a particularly useful contribution as foreign data has been available on a SITC basis only (the Kelly definition has also been concorded to SITC).

In a recent study, L. Davis (1982) developed a technique using input-output (I-O) analysis, and R&D expenditure and shipments data by product group to calculate a technology-intensity index. Based on the belief that the total R&D embodied in a product group presented a more accurate measure of technology intensity, Davis used an I-O matrix to determine the value of R&D embodied in the products (inputs) used to produce the product in question, and the percentage of that value which was contained in the final product. The value of the indirect R&D (R&D contributed by inputs) was then combined with the value of the direct R&D (R&D expenditures directly on the product development) to find total R&D. Davis next ranked product groups according to their total R&D to shipments intensity.

He then made another break with tradition by designating goods as high technology products (DOC3) only when they showed a significantly greater R&D intensity, rather than simply an above average R&D intensity.

Two consumer product groups, automobiles and radio and television receivers, were excluded from the high technology products in the analysis of international trade performance in this report. Though including these two product groups would have revealed an even larger deterioration of the U.S. position, the evidence supporting their inclusion is ambiguous. Neither the DOC2 nor the DOC3 definitions identified automobiles as technology intensive and recent, more disaggregated R&D expenditures data show radio and television receivers to be below average in technology intensity.

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DOC1 DEFINITION OF HIGH TECHNOLOGY INDUSTRIES

High-Technology Industries[1]

Description	SIC[2] Number
(1) Drugs and medicinals	283
(2) Office, computing, and accounting equipment	357
(3) Radio, television, and communications equipment, and electronic components:	
Radio- and TV-receiving equipment, except communications types	365
Communications equipment	366
Electronic components and accessories	367
(4) Electrical apparatus and equipment: (excludes categories 365, 366 and 367)	36
(5) Aerospace and missiles:	
Aircraft and parts	372
Guided missiles and spacecraft	376
(6) Instruments and related products	38

TECHNOLOGY-INTENSIVE INDUSTRIES[3]

Description	SIC Number
(1) Chemicals and related products	28
(2) Nonelectrical machinery	35
(3) Electrical and electronic equipment	36
(4) Transportation equipment, missiles, and ordnance	37
(5) Instruments and related products	38

[1] As a general proposition technology-intensive industries are defined as those industries which normally spend 5 percent or more of their gross product (BEA concept of value added) on R&D and/or normally 5 percent or more of their total employment consists of "natural" scientists, engineers and technicians. High-technology industries normally spend at least 10 percent of their gross product (value added) on R&D and/or at least 10 percent of their total employment consists of "natural scientists, engineers and technicians."

[2] Standard Industrial Classification.

[3] Includes industries classified as high technology.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Economic and National Security Implications," Draft, International Trade Administration, U.S. Department of Commerce, March 1982.

DOC2 DEFINITION OF HIGH TECHNOLOGY PRODUCTS

Description	SITC[1] Number
(1) Aircraft and parts (SIC 372):	
Aircraft engines includes: internal combustion engines, and jet and gas turbines for aircraft	711.4
Aircraft includes: Aircraft, heavier-than-air; airships and balloons; and parts of aircraft, airships and balloons	734
(2) Office, computing, and accounting machines (SIC 357):	
Office machines includes: typewriters and check writing machines; calculating, accounting and similar machines (includes electronic computers); statistical machines; and office machines and parts not specified elsewhere	714
Weighing machinery and weights therefor	719.63
(3) Electrical transmission and distribution equipment (SIC 361, 362, 366 & 367):	
Electrical power machinery and switchgear	722
Telecommunications equipment: not elsewhere specified, includes: electrical line and telegraph equipment; microphones, loudspeakers and amplifiers; and other telecommunications equipment	724.9
Thermionic, etc., valves and tubes, photocells, transitors	729.3
Electron and proton accelerators	729.7
Phonograph records, recorded tapes, and other recorded media	891.2
(4) Optical and medical instruments (SIC 383-387):	
Pharmaceutical goods	541.9
Photographic and optical goods, watches and clocks	86 (excluding 861.8 and 861.9)
(5) Drugs and medicines (SIC 283):	
Medicinal and pharmaceutical products (Does not include 541.9)	541

Description	SITC Number[1]
(6) Plastic materials and synthetics (SIC 282):	
Plastic materials, regenerated cellulose, and resins	581
Yarn and thread of synthetic fibers	651.6
(7) Engines and turbines (SIC 351):	
Steam engines	711.3
Internal combustion engines (other than for aircraft)	711.5
Gas turbines (other than for aircraft)	711.6
Engines not specified elsewhere	711.8
(8) Agricultural chemicals (SIC 287):	
Manufactured fertilizers	561
Insecticides, fungicides, disinfectants and similar preparations	599.2
(9) Professional, scientific, and measuring instruments (SIC 381 & 382):	
Electrical measuring and controlling instruments and apparatus	729.5
Meters and counters, nonelectric	861.8
Measuring, controlling, and scientific instruments, not specified elsewhere	861.9
(10) Industrial chemicals (SIC 281):	
Chemical compounds and elements	51
Synthetic organic dyestuffs, natural indigo and color lakes	531
Synthetic tanning materials	432.3
Coloring materials not specified elsewhere	533.1
Essential oils and resinoids	551.1
(11) Radio and TV receiving equipment (SIC 365):	
Television broadcast receivers	724.1
Radio broadcast receivers	724.2
Phonographs, tape recorders and other sound recorders and reproducers	891.1

[1] Standard International Trade Classification, Revision 1.

NOTE: Kelly did not include the portion of guided missiles and spacecraft found in ordnance and accessories in the definition of high technology products, as these products are not included in the U.N. classification of manufactured products (SITC 5-8). Aircraft and parts (SITC 734) do include products related to spacecraft.

SOURCES: Kelly, R.K., "The Impact of Technological Innovation on International Trade Patterns," Office of International Economic Research, U.S. Department of Commerce, December 1977.

United Nations, "Standard International Trade Classification Revised," Statistical Papers Series M No. 34, 1961.

DOC3 DEFINITION OF HIGH TECHNOLOGY PRODUCTS

	Description	SIC[1] Number
(1)	Guided missiles and spacecraft	376
(2)	Communications equipment and electronic components:	
	Radio- and TV-receiving equipment, except communications types	365
	Communications equipment	366
	Electronic components and accessories	367
(3)	Aircraft and parts	372
(4)	Office, computing, and accounting machines	357
(5)	Ordnance and accessories, except vehicles and guided missiles	348
(6)	Drugs and medicines	283
(7)	Industrial inorganic chemicals	281
(8)	Professional and scientific instruments (excludes category 3825)	38
(9)	Engines and turbines	351
(10)	Plastic materials and synthetic resins, synthetic rubber and other man-made fibers, except glass	282

[1] Standard Industrial Classification.

SOURCES: Davis, L.A., "Technology Intensity of U.S. Output and Trade," Office of Trade and Investment Analysis, U.S. Department of Commerce, February 1982.

Standard Industrial Classification Manual, 1972, Office of Management and Budget, 1972.

APPENDIX B

STATISTICAL TABLES

Table 1

SOME BASIC INDICATORS, 1978

	United States	Japan	West Germany	France
Population (millions)	218.5	114.9	61.3	53.2
Annual Growth*	0.8 %	1.2 %	0.1 %	0.6 %
Labor Force (millions)	102.5	55.3	25.2	22.4 [1]
Annual Growth*	2.2 %	0.9 %	-0.7 %	0.7 %
GNP Per Capita (U.S. Dollars)	$9,770	$7,700	$10,300	$8,880
Annual Real*	2.3 %	7.8 %	2.4 %	3.1 %
Higher Education (as % of Age Group)	41.0 %	24.7 %	13.6 %	18.8 %

[1] 1977

* Since 1970

SOURCES: 1980 World Bank Atlas
Organization for Economic Cooperation and Development (OECD) educational statistics

Table 2

U.S. AND JAPANESE MERCHANDISE TRADE WITH THE WORLD
(In billions of U.S. dollars)

	UNITED STATES[1]			JAPAN[2]		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1960	19.7	15.1	4.6	4.1	4.5	-0.4
1967	31.0	26.9	4.1	10.4	11.7	-1.3
1968	34.1	33.2	0.8	13.0	13.0	-
1969	37.3	36.0	1.3	16.0	15.0	1.0
1970	42.7	40.0	2.7	19.3	18.9	0.4
1971	43.5	45.6	-2.0	24.0	19.7	4.3
1972	49.2	55.6	-6.4	28.6	23.5	5.1
1973	70.8	69.5	1.3	36.9	38.2	-1.3
1974	97.9	100.3	-2.3	55.6	62.0	-6.4
1975	107.7	98.5	9.1	55.8	57.9	-2.1
1976	115.2	123.5	-8.3	67.2	64.8	2.4
1977	121.2	160.5	-39.4	80.5	70.8	9.7
1978	143.7	186.0	-42.4	97.5	79.3	18.2
1979	181.9	222.3	-40.4	103.0	110.7	-7.7
1980	220.6	257.0	-36.4	129.8	140.5	-10.7

1 U.S. imports are on a cost of merchandise basis (fas) prior to 1977. From 1977 through 1980, U.S. imports are on a cost of merchandise, insurance and freight basis (cif).

2 Japan's exports are on a customs value basis, imports are cif.

SOURCE: "International Economic Indicators," International Trade Administration, Department of Commerce, Various issues.

Table 3

WEST GERMAN AND FRENCH MERCHANDISE TRADE WITH THE WORLD
(In billions of U.S. dollars)

	WEST GERMANY[1]			FRANCE[2]		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1960	11.4	10.2	1.2	7.2	5.9	1.3
1967	21.8	17.5	4.3	11.4	11.6	-0.2
1968	24.9	20.3	4.6	12.9	13.0	-0.1
1969	29.1	25.1	4.0	15.4	16.5	-1.1
1970	34.2	29.9	4.3	18.1	17.9	0.2
1971	39.1	34.5	4.6	20.7	19.8	0.9
1972	46.2	39.9	6.3	26.4	25.3	1.1
1973	67.5	54.8	12.7	36.6	35.3	1.3
1974	89.3	69.6	19.7	46.6	49.9	-3.3
1975	90.2	74.9	15.3	53.0	51.4	1.6
1976	102.2	88.4	13.8	57.0	61.4	-4.4
1977	118.1	101.5	16.6	65.0	70.5	-5.5
1978	142.5	121.8	20.7	79.1	81.6	-2.5
1979	171.6	159.3	12.3	100.6	107.5	-6.9
1980	192.9	188.0	4.9	116.1	135.0	-18.9

1 West German imports are on a cif basis.

2 French imports are on a cost of merchandise and loading for shipment (fob) basis before 1977 and on a cif basis from 1977 through 1980.

SOURCE: "International Economic Indicators," International Trade Administration, U.S. Department of Commerce, Various issues.

Table 4

U.S. AND JAPANESE MANUFACTURED PRODUCTS TRADE
WITH THE WORLD
(In billions of U.S. dollars)

	UNITED STATES[1]			JAPAN[2]		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1960	12.7	6.8	5.9	3.6	1.0	2.6
1967	21.1	15.8	5.3	9.8	3.1	6.7
1968	24.1	20.6	3.5	12.2	3.5	8.7
1969	27.1	23.0	4.1	15.0	4.4	10.6
1970	29.7	25.9	3.4	18.1	5.6	12.5
1971	30.8	30.4	0.4	22.6	5.5	17.1
1972	34.3	37.8	-3.5	27.1	6.8	20.3
1973	45.6	45.0	0.6	34.8	11.5	23.3
1974	64.6	55.2	9.3	52.5	14.5	38.0
1975	71.0	51.1	19.9	53.2	11.5	41.7
1976	77.2	64.8	12.5	64.6	13.4	51.2
1977	80.2	81.9	-1.8	77.7	14.7	63.0
1978	94.5	106.8	-12.3	94.2	20.0	74.2
1979	116.6	118.8	-2.1	99.1	27.1	72.0
1980	143.9	131.5	12.5	124.4	30.7	93.7

1 U.S. imports are on a fas basis prior to 1977 and on a cif basis from 1977 through 1980.

2 Japan's imports are on a cif basis for all years.

SOURCE: "International Economic Indicators," International Trade Administration, U.S. Department of Commerce, Various issues.

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Table 5

WEST GERMAN AND FRENCH MANUFACTURED PRODUCTS TRADE
WITH THE WORLD
(In billions of U.S. dollars)

	WEST GERMANY[1]			FRANCE[2]		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1960	10.1	4.2	5.9	5.1	2.4	2.7
1967	19.5	8.5	11.0	8.4	7.0	1.4
1968	22.3	10.6	11.7	9.4	8.4	1.0
1969	26.2	13.9	12.3	11.0	10.9	0.1
1970	30.7	17.4	13.3	13.5	12.0	1.5
1971	35.0	20.0	15.0	15.1	13.3	1.8
1972	41.5	23.8	17.7	19.1	15.7	3.4
1973	60.3	31.6	28.7	26.1	23.8	2.3
1974	78.9	36.5	42.4	33.2	30.2	3.0
1975	79.6	50.0	29.6	39.6	30.7	8.9
1976	90.7	48.6	42.1	42.5	37.6	4.9
1977	104.3	57.4	46.9	48.7	40.7	8.0
1978	125.2	71.7	53.3	58.8	49.2	9.6
1979	150.6	91.4	59.2	75.6	64.1	11.5
1980	166.9	103.8	63.1	84.0	76.6	7.4

1 West German imports are on a cif basis.

2 French imports are on a cost of merchandise and loading for shipment (fob) basis before 1977 and on a cif basis from 1977 through 1980.

SOURCE: "International Economic Indicators," International Trade Administration, U.S. Department of Commerce, Various issues.

Table 6

CLASSIFICATION OF U.S. MANUFACTURING INDUSTRIES IN ACCORDANCE WITH THEIR TECHNOLOGICAL INTENSITY

Industry Groupings	Criteria of Intensity: 1. Expenditures on R&D as Percent of Gross Product Originated (BEA Concept of Value Added), %			2. Employment of Scientists, Engineers and Technicians Working with R&D and All Other Functions as Percent of Total Employment %		
	1961	1970	1980	1961	1970	1980
A. All Manufacturing Industries	7.4	6.9	7.2	5.4	5.9	6.1
B. Technology-Intensive Industries:[1]						
o Chemicals and Related Products (SIC 28)	10.1	9.7	10.0	13.9	14.7	13.1
o Nonelectrical Machinery (SIC 35)	6.9	6.3	8.2	8.5	8.7	10.6
o Electrical and Electronic Equipment (SIC 36)	20.8	19.2	15.8	14.3	14.3	13.3
o Transportation Equipment Missiles and Ordnance (SIC 37)	26.4	22.6	22.9	10.7	12.1	11.0
o Instruments and Related Products (SIC 38)	8.3	10.9	13.3	13.6	13.2	13.3
Technology-Intensive, Average	16.9	14.8	14.2	11.7	12.2	11.9
B1. High Technology Industries:[1]						
- Drugs and Medicinals (SIC 283)	11.2	16.9	22.1	17.8	16.8	18.1
- Office, Computing and Accounting equipment (SIC 357)	28.5	36.2	33.2	NA	19.5	15.6
- Radio, Television, Communications Equipment and Electronic Components (SIC 365, 366, and 367)	24.2	23.7	16.4	18.7	18.1	18.5
- Electrical Apparatus and equipment (SIC 36 Minus SIC 365, 366, and 367)	17.6	14.5	14.7	9.7	10.2	6.3
- Aerospace and Missiles (SIC 372 and 376)	50.7	39.6	45.9	11.1	19.3	15.6
- Instruments and Related Products (SIC 38)	8.3	10.9	13.3	13.6	13.2	13.3
High Technology, Average	27.6	24.6	23.2	13.3[2]	16.0	15.5

Table 6 (cont'd.)

CLASSIFICATION OF U.S. MANUFACTURING INDUSTRIES IN ACCORDANCE WITH THEIR TECHNOLOGICAL INTENSITY--Cont.

Industry Groupings	Criteria of Intensity: 1. Expenditures on R&D as Percent of Gross Product Originated (BEA Concept of Value Added), %			2. Employment of Scientists, Engineers and Technicians Working with R&D and All Other Functions as Percent of Total Employment %		
	1961	1970	1980	1961	1970	1980
B2. Technology-Intensive Other Than the High-Technology Industries:						
-- Chemicals Except Drugs and Medicinals (SIC 28 Minus SIC 283)	10.0	8.3	7.6	13.3	14.3	12.0
-- Nonelectrical Machinery Except Office, Computer and Accounting Equipment (SIC 35 Minus SIC 357)	4.5	2.3	2.9	NA	6.9	6.9
-- Motor Vehicles and Equipment (SIC 371)	9.9	10.4	15.9[3]	4.5	6.3	3.6
-- Transportation Equipment Other Than Motor Vehicles, Aircraft and Missiles (SIC 37 Minus SIC 371, 372 and 376)	3.1	2.1	1.2	27.8	4.1	17.0
B2. Average	7.8	6.2	6.8	11.6[4]	8.3	8.3
C. Not Technology-Intensive Industries,[5] Average	1.3	1.4	1.7	2.0	2.0	2.1

Sources: Bureau of Economic Analysis (BEA), Bureau of the Census, Bureau of Labor Statistics and National Science Foundation.

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Footnotes for Table 6

[1] As a general proposition technology-intensive industries are defined as those industries which normally spend 5 percent or more of their gross product (BEA concept of value added) on R&D and/or normally 5 percent or more of their total employment consists of "natural" scientists, engineers and technicians. High-technology industries normally spend at least 10 percent of their gross product (value added) on R&D and/or at least 10 percent of their total employment consists of "natural" scientists, engineers and technicians.

[2] Net of the office, computing, and accounting equipment industry (SIC 357).

[3] Evidently inflated due to the recession of 1980. In 1979 the proportion was 11.7 percent.

[4] Net of nonelectrical machinery industries other than SIC 357.

[5] Consistent with the definition of technology-intensive, not-technology-intensive industries are industries that spend up to 5 percent of their gross product (value added) on R&D and/or up to 5 percent of their total employees are "natural" scientists, engineers and technicians. In reality, most of the U.S. industries other than those classified as technology-intensive normally spend only between 1 and 2 percent of their gross product on R&D, and only about 2 percent of the persons they employ are scientists, engineers and technicians.

SOURCE: Boretsky, M. "The Threat to U.S. High Technology Industries: Economic and National Security Implications," International Trade Administration, U.S. Department of Commerce, March 1982.

Table 7

RESEARCH-INTENSITY RATIOS[1], THE DOC2 DEFINITION OF HIGH TECHNOLOGY PRODUCTS

SITC CLASS	DESCRIPTION	RESEARCH INTENSITY RATIO (PERCENT)
711.4, 734	Aircraft and Parts	12.41
714, 719.63	Office, computing and accounting machines	11.61
722, 724.9, 729.3, 729.7, 891.2	Electronic transmission and distribution equipment; electrical industrial apparatus; communication equipment and electronic components	11.01
541.9, 86 (excluding 861.8, 861.9)	Optical and medical instruments, photos, and watches	9.44
541 (excluding 541.9)	Drugs and medicines	6.94
581, 561.6	Plastic materials and synthetics	5.62
711.3, 711.5, 711.6, 711.8	Engines and Turbines	4.76
561, 599.2	Agricultural chemicals	3.64
729.5, 861.8 861.9	Professional, scientific, and measuring instruments	3.17
51, 531, 532.3, 533.1, 551.2	Industrial chemicals	2.78
724.1, 724.2, 891.1	Radio and TV receiving equipment	2.57
5-8	Total manufacturing	2.36[2]

[1] The ratio of applied R&D funds by product field to shipments by product class.

[2] This is the average intensity of all manufactured products.

SOURCE: Kelly, R.K. "The Impact of Technological Innovation on International Trade Patterns." Office of International Economic Research, U.S. Department of Commerce. December 1977.

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Table 8

U.S. MANUFACTURES RANKED BY TOTAL EMBODIED R&D[1], THE DOC3 DEFINITION OF HIGH TECHNOLOGY PRODUCTS[2]

SIC CLASS	DESCRIPTION	TOTAL INTENSITY[3] (PERCENT)
376	Guided missiles and spacecraft	63.86
365, 366, 367	Communications equipment and electronic components	16.04
372	Aircraft and parts	15.40
357	Office, computing, and accounting machines	13.65
348	Ordnance and accessories	13.64
283	Drugs and medicines	8.37
281	Industrial inorganic chemicals	8.23
38 (excluding 3825)	Professional and scientific instruments	5.70
351	Engines, turbines and parts	5.49
282	Plastic and synthetic materials	5.42
	Weighted average all manufacturers	3.30

[1] The total of direct and indirect R&D expenditures.

[2] High technology products are defined as those having significantly higher R&D embodied in them. Plastic and synthetic materials have 30 percent more R&D embodied in them than agricultural chemicals (the next group of products in the ranking).

[3] Total R&D expenditures, both direct and indirect, as a percentage of product shipments.

SOURCE: Davis, L.A. "Technology Intensity of U.S. Output and Trade," Office of Trade and Investment Analysis, U.S. Department of Commerce, February 1982.

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Table 9

TRENDS IN U.S. MERCHANDISE TRADE BALANCES OF BASIC
COMMODITY GROUPS, THE DOCI DEFINITION
SELECTED YEARS 1951-1980
(In Billions of U.S. Dollars)

Item	Average 1951-1955	1960	1966	1971	1976	1980
A. Trade largely dependent on relative endowment in natural resources:						
1. Agricultural products	-1.2	+1.0	+2.3	+1.9	+11.8	+23.8
2. Raw material & energy	-2.0	-1.7	-3.1	-4.1	-30.6	-62.3
A. Total	-3.2	-0.7	-0.8	-2.2	-18.8	-44.5
B. Trade largely dependent on technology and other competitive forces:						
1. Technology-intensive manufactured products[1]	+5.7	+6.6	+8.4	+8.3	+25.7	+42.5
2. Not technology-intensive manufactured products[1]	+1.8	-0.9	-3.6	-8.3	-13.2	-21.5
B. Total (All manufactures)	+7.5	+5.7	+4.8	0.0	+12.7	+21.0
C. Total Merchandise Trade[2]	+4.6	+5.5	+4.8	-1.5	-5.7	-20.1

\+ denotes surplus

\- denotes deficit

[1] For definition see Table 6.

[2] Includes commodities not classified by kind, "special category" commodities and reexport of foreign merchandise.

SOURCE: U.S. Department of Commerce

Table 10

COMPARATIVE TRADE BALANCES (F.O.B) IN DOC[1] TECHNOLOGY-INTENSIVE MANUFACTURED PRODUCTS[1] BY COUNTRY AND AREA

(In Billions of U.S. Dollars)

Area	United States			Japan			West Germany			France		
	1970	1976	1980	1970	1976	1980	1970	1976	1980	1970	1976	1978
World	10.4	26.8	42.4	6.9	35.7	70.9	13.4	40.3	64.6	1.4	6.7	10.0
United States	--	--	--	1.2	7.3	16.4	.9	1.5	2.7	-.7	-1.5	-3.6
Canada	.9	4.2	6.6	.2	.9	1.4	.2	.5	.7	.0	.0	.1
Japan	-1.0	-6.9	-16.3	--	--	--	.2	-.5	-2.2	-.3	-.7	-1.3
Western Europe	2.3	4.6	9.4	.7	5.4	10.7	7.9	21.3	36.6	-.3	-1.0	-.4
West Germany	-.9	-1.7	-3.6	-.1	.6	2.3	--	--	--	-.8	-2.6	-4.0
France	.6	1.0	1.8	-.0	.5	.9	.9	3.0	5.1	--	--	--
United Kingdom	.5	.5	2.3	.1	.6	1.6	.3	1.5	3.2	-.2	-.0	.6
Italy	.2	.2	.6	-.0	.2	.3	.8	2.1	5.3	-.1	-.0	.8
Australia, New Zealand, South Africa	1.0	2.5	4.1	.5	2.2	3.9	.7	1.6	3.1	.2	.5	.7
Eastern Europe	.0	.1	.0	.0	.3	.4	.4	1.8	2.3	.2	.5	.7
USSR	.1	.6	.1	.1	.8	1.1	.2	1.5	2.0	.2	.4	.8
China	--	.1	.7	.2	.6	2.5	.1	.3	.8	.0	.3	.1
OPEC	1.2	8.5	10.9	.4	5.1	10.7	.7	6.3	8.6	.5	3.4	5.7
All Others	6.0	13.3	26.9	3.5	13.3	23.8	2.2	6.0	10.0	1.4	4.5	7.2
NIC's	1.4	3.3	9.1	1.4	5.1	11.6	.4	.8	1.9	.16	.4	.3

[1] Includes SITC Rev. Nos. 5 (Chemicals), 7 (Machinery and Transport Equipment), 86 (Professional and Scientific Instruments), 891 (Sound Recorders, Producers). The industries producing these products spend 5 percent or more of their gross product (BEA concept of value added) on R&D and/or 5 percent or more of their total employees are "natural" scientists, engineers, and technicians.

SOURCE: United Nations

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Notes to Table 10

- The United States is doing all right if considered in isolation. As of 1980, however, U.S. balance was only 60 percent of Japan's and 65 percent of Germany's.
- The bulk of the U.S. surplus, 63 percent, is derived from trade with "All Other Countries"--largely non-OPEC LDC's, a market requiring continuous and most probably nonrepayable infusion of funds to remain viable. Japan derives from this source only 33.5 percent, and Germany only 15 percent.
- Both Japan and West Germany enjoy huge trade balances in technology-intensive products not only worldwide, but also with every trading partner in the table.
- France's position is weak vis-a-vis industrialized countries, but fairly strong and getting stronger in other countries.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Ecconomic and National Security Implications," Draft Report, International Trade Administration, U.S. Department of Commerce. March 1982.

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Table 11

COMPARATIVE TRADE BALANCES (F.O.B) IN DOC1 TECHNOLOGY-INTENSIVE MANUFACTURED PRODUCTS[1] BY COUNTRY AND AREA

(In Billions of U.S. Dollars)

Area	United States			Japan			West Germany			France		
	1970	1976	1980	1970	1976	1980	1970	1976	1980	1970	1976	1980
World	4.8	10.2	15.2	2.3	10.5	21.7	2.5	6.8	9.1	.2	1.2	1.7
United States	--	--	--	.7	3.2	3.4	-.3	-.7	-1.2	-.4	-1.2	-2.1
Canada	.9	1.8	.8	.1	.4	.5	-.0	.1	.1	.0	.0	.0
Japan	-.5	-2.7	-3.5	--	--	--	-.1	-.6	-1.4	-.0	-.3	-.8
Western Europe	2.2	4.0	8.2	.3	2.1	5.0	1.8	4.7	7.5	-.1	-.5	-.1
West Germany	.4	.6	1.2	.1	.6	1.6	--	--	--	-.0	-.0	-.0
France	.3	.6	1.1	.0	.2	.4	.2	.8	.9	--	--	--
United Kingdom	.4	.5	1.8	.0	.2	.7	-.0	-.0	-.0	-.1	-.1	-.1
Italy	.2	.5	.7	-.0	.0	.2	.1	.6	1.3	-.1	-.2	-.1
Australia, New Zealand, South Africa	.3	.9	1.6	.1	.7	.9	.2	.4	.6	.1	.2	.2
Eastern Europe	.0	.4	.1	.0	.1	.2	.1	.2	.4	.0	.2	.1
USSR	.0	.1	.1	.0	.1	.2	.0	.2	.2	.0	.0	.1
China	--	.0	.3	.0	.1	.5	.0	.1	.0	.0	.1	.0
OPEC	.3	2.9	3.8	.1	.4	3.4	.1	1.3	1.9	.2	.9	1.7
All Others	1.7	3.8	4.6	.4	1.2	3.0	.5	1.0	1.4	.4	1.2	2.6
NIC's	.2	-.2	.8	.5	1.5	4.5	.1	-.0	-.3	.0	.1	-.1

[1] Includes Medicinal Products (SITC 54), Calculating Machines including Computers (SITC 7114.2), Electrical Machinery, Apparatus and Appliances (SITC 72), Aircraft (SITC 734), Jet Engines (SITC 711.4(2), Professional Scientific and Controlling Instruments (SITC 86). Industries producing these products spend 10 percent or more of their gross product (BEA concept of value added) on R&D, and/or 10 percent or more of their total employees are "natural" scientists, engineers, and technicians.

SOURCE: United Nations

Notes to Table 11:

- o U.S. balances are positive with all trade partners, except Japan.
- o Japan's balances are positive with all trade partners.
- o The United States, Germany, France, and Italy allow trade deficits with NIC's, but not Japan. 54 Percent of U.S. trade balance is derived from trade with Western Europe and 30 percent from trade with "All Other Countries"--largely non-OPEC LDC's.
- o France has the weakest position in high technology trade.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Ecconomic and National Security Implications," Draft Report, International Trade Administration, U.S. Department of Commerce. March 1982.

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Table 12

COMPARATIVE CHANGES IN WORLD (OECD) EXPORT SHARES BY DOC1 CCOMMODITY GROUP FROM 1970 TO 1980

(In Percent)

Commodity Group	United States 1970	United States 1980	United States Change From 1970-1980	Japan 1970	Japan 1980	Japan Change From 1970-1980	West Germany 1970	West Germany 1980	West Germany Change From 1970-1980	France 1970	France 1980	France Change From 1970-1980
Total Merchandise Trade	15.4	12.0	-3.4	8.9	10.6	+1.7	15.7	15.6	-0.1	8.1	9.0	+0.9
Manufacturers (Total)	18.4	16.4	-2.0	8.9	11.0	+2.1	19.8	19.8	0.0	9.1	10.2	+1.1
- Economically Strategic Manufactured Products	14.4	9.9	-4.5	13.3	23.4	+10.1	22.2	21.5	-0.7	9.6	10.6	+1.0
-- Metalworking Machinery	16.5	11.0	-5.5	4.8	16.1	+11.3	34.7	29.4	-5.3	5.6	5.7	+0.1
-- Steel	9.0	5.0	-4.0	21.5	25.6	+4.1	18.4	18.6	+0.2	10.9	11.3	+0.4
-- Road Vehicles	17.4	12.1	-5.3	9.2	23.5	+14.3	23.1	22.3	-0.8	9.3	10.7	+1.4
-- Technology-Intensive Products[1]	23.1	19.9	-3.2	9.7	14.5	+4.8	20.4	19.3	-1.1	1.6	9.0	+1.4
-- High Technology Products[2]	29.9	26.1	-3.8	11.9	15.8	+3.9	14.6	15.7	+1.1	7.2	7.8	+0.6
--- Drugs and Medicinals	17.1	15.8	-1.3	2.7	2.3	-0.4	19.9	17.6	-2.3	9.3	11.6	+2.3
--- Business Machines and Equipment	37.7	37.0	-0.7	8.0	9.9	+1.9	15.1	13.0	-2.1	7.8	7.8	0.0
--- Computers	31.5	35.5	+4.0	11.1	12.3	+1.2	11.2	12.1	+0.9	9.0	7.1	-1.9
-- Electrical and Electronic Machines and Equipment	21.6	18.0	-3.6	10.3	18.7	+8.4	19.5	18.7	-0.8	8.1	9.2	+1.1
--- Telecommunications Equip.	21.9	18.1	-3.8	11.9	23.1	+11.2	15.2	14.6	-0.6	5.5	7.7	+2.2

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Table 12 (Continued)

Commodity Group	United States 1970	United States 1980	United States Change From 1970-1980	Japan 1970	Japan 1980	Japan Change From 1970-1980	West Germany 1970	West Germany 1980	West Germany Change From 1970-1980	France 1970	France 1980	France Change From 1970-1980
--- Electronic Components	39.8	27.6	-12.2	6.3	27.0	+20.7	12.5	14.3	+1.8	8.6	8.8	+0.2
--- Consumer Electronics	9.3	9.9	+0.6	49.0	53.0	+4.0	14.3	12.0	-2.3	2.3	5.5	+2.2
--- Jet Engines	40.4	32.0	-8.4	0.1	0.1	0.0	5.4	5.3	-0.1	5.6	7.8[3]	+2.2
--- Aircraft	66.0	53.1	-12.9	0.8	0.4	-0.4	2.9	10.7	+7.8	7.6	9.1	+1.5
--- Scientific Instruments	29.3	26.8	-2.5	8.7	10.4	+1.7	21.5	19.4	-2.1	7.1	8.1	+1.0
-- Technology-Intensive Other Than High Technology Products	20.4	17.3	-3.1	8.8	14.0	+5.2	22.3	20.7	-1.6	7.8	9.4	+1.6
- Not Technology-Intensive Products	10.4	10.1	-0.3	13.7	13.0	-0.7	16.3	16.8	+0.5	9.3	9.9	+0.6
-- Textiles	6.6	9.9	+3.3	18.7	13.7	-5.0	16.0	16.8	+0.8	9.9	9.2	-0.7
-- Apparel	4.6	+5.4	+0.8	11.3	2.2	-9.1	9.7	12.9	+3.2	10.9	11.4	+0.5

[1] Technology-intensive products are produced by industries in which spending on R&D is 5 percent or more of gross product (BEA concept of value added) and/or "natural" scientists, engineers, and technicians comprise 5 percent or more of total employment.

[2] High-technology products are produced by industries in which spending on R&D is 10 percent or more of gross product (value added) and/or "natural" scientists, engineers, and technicians comprise 10 percent or more of total employment.

[3] Average for 1979-1980.

SOURCE: Individual country data as reported to United Nations.

Notes to Table 12:

- o From 1970 to 1980, U.S. industries lost a portion of their export market shares in all major product groups and in most specific product categories except in computers, consumer electronics and the two most important "downmarket" products--textiles and apparel;

- o In the defined product groups, U.S. industries' losses of market shares were greatest in "economically strategic products," (4.5 percentage points), followed by high technology products (loss of 3.8 percentage points) and the technology-intensive products other than high technology (loss of 3.1 percentage points);

- o In specific product lines, U.S. industries' losses were greatest in aircraft (12.9 percentage points), followed by electronic components (12.2 percentage points), jet engines (8.4 percentage points), metalworking machinery (5.5 percentage points), automobiles (5.3 percentage points), and steel (4.0 percentage points);

- o In the "downmarket" not technology-intensive products groups, U.S. industries lost only 3/10 of one percent of their shares and, as already noted, in textiles and apparel U.S. industries improved their shares.

The performance of Japanese industries in the ten year period was for essentially the reverse of the performance of U.S. industries:

- o Of the defined product groups, Japanese industries achieved the greatest gain in "economically strategic products" (10.1 percentage points), followed by a gain of 5.2 percentage points in technology-intensive, and a gain of 3.8 percentage points in high technology products (almost identical with U.S. losses). In the "downmarket" not technology-intensive product group, however, the Japanese lost 7/10 of one percent of their market share;

- o In specific product lines, Japanese industries' gains were relatively greatest in electronic components (gain of 20.7 percentage points), followed by automobiles (gain of 14.3 percentage points), metalworking machinery (gain of 11.3 percentage points), telecommunications equipment (gain of 11.2 percentage points), and steel (further gain of 4 percentage points). However, in textiles Japan lost 5 percentage points of its previous market, and in apparel it lost 9.1 percentage points.

Over the ten year period, France gained in practically all product groups and specific product lines. Most of its gains, however, were relatively small.

The German score was rather mixed, but a small gain was registered in the high technology product group.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Economic and National Security Implications," Draft Report, International Trade Administration, U.S. Department of Commerce. March 1982.

Table 13

COMPARATIVE CHANGES IN WORLD[1] EXPORT SHARES OF ALL MANUFACTURED PRODUCTS AND DOC1 TECHNOLOGY-INTENSIVE PRODUCTS[2] FROM 1955 to 1980

(In Percent)

Country and Product Group	1955	1960	1970	1980	Change From 1955-1980
United States					
All Manufactured Products	25.9	22.8	18.4	16.4	-9.5
Technology-Intensive Products	35.5[3]	27.6	23.1	19.9	-15.6
Japan					
All Manufactured Products	4.8	6.5	8.9	11.0	+6.2
Technology-Intensive Products	1.8[3]	4.2	9.7	14.5	+12.7
West Germany					
All Manufactured Products	14.6	18.2	19.8	19.8	+5.2
Technology-Intensive Products	17.6[3]	21.2	20.4	19.3	+1.7
France					
All Manufactured Products	8.8	9.1	8.3	10.2	+1.4
Technology-Intensive Products	6.4[3]	7.7	7.6	9.0	+2.6

1 "World" exports are defined as the sum of the exports from 14 or 15 most important OECD (industrial) countries. The listed countries' percentages differ very little depending on whether the sume of the 14 or 15 countries is used in the calculation.

2 For definition of technology-intensive products, see Table 6.

3 1954.

SOURCES: United Nations, OECD, National Institute of Economic and Social Research (London), and U.S. Department of Commerce.

Table 14

U.S. AND JAPANESE HIGH TECHNOLOGY TRADE WITH THE WORLD
(In billions of U.S. dollars)

	UNITED STATES			JAPAN		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	4.6	1.0	3.6	0.6	0.6	0.1
1963	4.7	1.1	3.6	0.7	0.7	0.1
1964	5.4	1.4	4.0	0.9	0.8	0.2
1965	6.2	1.8	4.4	1.3	0.7	0.6
1966	6.9	2.6	4.3	1.7	0.8	0.9
1967	8.0	2.7	5.2	1.9	1.0	0.9
1968	9.5	3.4	6.1	2.5	1.2	1.3
1969	10.6	4.0	6.6	3.2	1.4	1.8
1970	12.2	5.0	7.3	4.0	2.0	1.9
1971	13.1	5.8	7.4	4.8	2.2	2.7
1972	14.0	7.4	6.7	6.1	2.5	3.7
1973	18.8	9.4	9.4	8.0	3.6	4.4
1974	26.4	11.7	14.8	11.1	5.0	6.1
1975	27.8	11.4	16.4	11.1	4.2	7.0
1976	31.0	15.4	15.7	14.2	4.9	9.4
1977	33.2	17.8	15.4	17.6	5.3	12.2
1978	40.2	23.5	16.8	23.2	6.9	16.4
1979	51.0	27.2	23.7	26.1	9.3	16.7
1980	63.3	32.8	30.5	32.5	11.2	21.3

NOTE: The high_tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a cost of merchandise ("free free along side," or fas) basis prior to 1977 and on a cost of the merchandise, insurance and freight (cif) basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 15

WEST GERMAN AND FRENCH HIGH TECHNOLOGY TRADE WITH THE WORLD
(In billions of U.S. dollars)

	WEST GERMANY			FRANCE		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	2.7	1.0	1.7	1.2	0.9	0.3
1963	3.1	1.1	2.0	1.3	1.0	0.2
1964	3.5	1.3	2.1	1.5	1.3	0.2
1965	3.9	1.7	2.1	1.7	1.4	0.4
1966	4.5	1.9	2.6	2.0	1.7	0.3
1967	5.0	2.1	3.0	2.3	2.0	0.3
1968	5.7	2.5	3.2	2.4	2.3	0.1
1969	6.7	3.2	3.6	2.9	2.9	0.0
1970	8.1	4.2	3.9	3.3	3.3	-0.0
1971	9.1	4.9	4.2	3.7	3.7	-0.0
1972	10.8	5.6	5.2	4.6	4.8	-0.2
1973	15.7	7.7	8.0	6.4	6.6	-0.2
1974	21.5	9.9	11.5	8.6	8.8	-0.2
1975	20.3	10.8	9.5	9.8	8.7	1.0
1976	24.1	13.3	10.9	11.3	10.5	0.8
1977	27.6	15.7	11.9	12.9	11.6	1.3
1978	33.5	20.0	13.5	16.3	14.5	1.8
1979	41.9	26.8	15.1	21.9	19.2	2.7
1980	46.5	30.8	15.7	23.8	23.2	0.6

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

Table 16

INDUSTRIAL-COUNTRY AND OECD HIGH TECHNOLOGY TRADE
(In billions of U.S. dollars)

	14 INDUSTRIAL COUNTRIES			OECD		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	15.3	9.1	6.2	15.4	9.9	5.5
1963	17.0	10.4	6.6	17.1	12.1	5.0
1964	19.5	12.3	7.2	19.7	14.3	5.4
1965	22.2	13.8	8.4	22.5	16.2	6.4
1966	25.4	16.3	9.1	25.8	19.0	6.7
1967	28.2	18.5	9.8	28.7	21.4	7.3
1968	32.9	21.7	11.2	33.5	24.9	8.5
1969	38.1	26.2	11.9	38.8	29.8	9.0
1970	44.6	31.5	13.1	45.5	35.8	9.7
1971	50.3	35.4	14.9	51.3	39.9	11.4
1972	59.0	42.1	16.8	60.3	47.7	12.6
1973	79.2	57.3	21.9	81.2	65.3	15.9
1974	108.9	75.4	33.5	112.0	86.3	25.8
1975	112.3	75.5	36.9	115.3	86.5	28.8
1976	129.0	88.9	40.1	132.8	100.9	31.9
1977	145.6	101.4	44.1	150.0	114.4	35.6
1978	181.1	128.7	52.4	186.6	143.6	43.0
1979	224.0	165.0	59.0	231.2	184.4	46.8
1980	264.9	194.6	70.3	274.7	215.9	58.9

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

The 14 industrial countries are: Austria, Belgium, Canada, Denmark, France, West Germany, Italy, Japan, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom, and United States. Belgium and Luxembourg report trade data as a unit, thus the reference to 14, rather than 15, countries. These countries account for approximately 80 percent of world trade in manufactured products.

All data are on a SITC REV1 basis as reported by the United Nations on the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

Table 17

U.S. HIGH TECHNOLOGY TRADE WITH JAPAN
(In billions of U.S. dollars)

YEAR	EXPORTS	IMPORTS	BALANCE
1962	0.2	0.1	0.1
1963	0.3	0.1	0.1
1964	0.3	0.2	0.1
1965	0.4	0.3	0.1
1966	0.5	0.4	0.0
1967	0.5	0.5	0.1
1968	0.6	0.6	-0.1
1969	0.8	0.9	-0.1
1970	1.1	1.2	-0.1
1971	1.1	1.4	-0.3
1972	1.2	1.9	-0.7
1973	1.6	2.3	-0.7
1974	2.3	2.7	-0.4
1975	1.7	2.5	-0.8
1976	2.0	4.1	-2.0
1977	2.1	4.8	-2.7
1978	2.8	6.2	-3.4
1979	4.1	6.6	-2.5
1980	4.9	7.7	-2.8

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 18

U.S. HIGH TECHNOLOGY TRADE WITH WEST GERMANY AND FRANCE
(In billions of U.S. dollars)

	WEST GERMANY			FRANCE		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	0.2	0.1	0.0	0.2	0.1	0.1
1963	0.2	0.2	0.0	0.2	0.0	0.1
1964	0.2	0.2	0.0	0.2	0.1	0.1
1965	0.4	0.2	0.2	0.3	0.1	0.3
1966	0.4	0.3	0.1	0.4	0.1	0.2
1967	0.5	0.3	0.2	0.4	0.1	0.3
1968	0.6	0.4	0.1	0.5	0.1	0.3
1969	0.7	0.5	0.2	0.5	0.1	0.3
1970	1.0	0.6	0.3	0.6	0.2	0.4
1971	1.0	0.7	0.3	0.6	0.2	0.4
1972	1.1	0.8	0.3	0.7	0.2	0.4
1973	1.3	1.0	0.2	1.0	0.3	0.6
1974	1.5	1.3	0.2	1.2	0.4	0.7
1975	1.7	1.1	0.6	1.1	0.5	0.7
1976	1.8	1.3	0.5	1.4	0.7	0.7
1977	2.0	1.5	0.5	1.5	0.7	0.8
1978	2.7	2.2	0.5	1.9	0.9	0.9
1979	3.3	2.5	0.9	2.4	1.2	1.2
1980	4.1	2.7	1.3	3.3	1.5	1.7

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 19

SHARES OF 14 INDUSTRIAL-COUNTRY HIGH TECHNOLOGY EXPORTS
(In percent)

YEAR	U.S. SHARE	JAPANESE SHARE	WEST GERMAN SHARE	FRENCH SHARE
1962	30.3	4.1	17.6	7.7
1963	27.8	4.4	18.5	7.6
1964	27.7	4.8	17.9	7.6
1965	28.0	5.9	17.4	7.8
1966	27.3	6.7	17.8	8.0
1967	28.2	6.8	17.8	8.0
1968	28.9	7.6	17.3	7.4
1969	27.9	8.5	17.7	7.6
1970	27.4	8.9	18.3	7.4
1971	26.1	9.6	18.0	7.4
1972	23.8	10.4	18.3	7.8
1973	23.8	10.1	19.9	8.1
1974	24.2	10.2	19.7	7.9
1975	24.8	9.9	18.1	8.7
1976	24.1	11.0	18.7	8.8
1977	22.8	12.1	18.9	8.8
1978	22.2	12.0	18.5	9.0
1979	22.7	11.6	18.7	9.8
1980	23.9	12.3	17.5	9.0

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

The "14 industrial countries" include: Austria, Belgium, Canada, Denmark, France, West Germany, Italy, Japan, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom, and United States. Belgium and Luxembourg report trade data as a unit, thus the reference to 14 rather than 15 countries. These countries account for approximately 80 percent of world trade in manufactured products.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

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Table 20

SHARES OF THIRD-COUNTRY MARKETS
(In percent)

YEAR	U.S. SHARE	JAPANESE SHARE	GERMAN SHARE	FRENCH SHARE	4 COUNTRY SHARE
1962	38.4	4.6	8.5	7.2	58.7
1963	35.3	5.0	8.5	7.8	56.6
1964	35.6	5.0	8.8	8.3	57.8
1965	36.2	4.0	10.1	8.0	58.3
1966	36.2	4.2	9.8	8.8	58.9
1967	37.5	4.7	9.6	9.2	61.0
1968	38.8	4.8	10.0	9.4	63.1
1969	38.2	5.2	11.4	10.3	65.1
1970	38.6	6.4	13.2	10.6	68.8
1971	36.8	6.0	13.6	10.5	66.9
1972	33.8	5.9	13.5	11.5	64.8
1973	33.4	6.3	13.7	11.7	65.1
1974	32.8	6.2	12.3	10.9	62.1
1975	33.1	4.9	12.8	10.4	61.2
1976	33.0	5.2	14.1	11.1	63.4
1977	31.3	5.0	14.8	10.9	62.1
1978	30.9	5.3	15.3	11.1	62.6
1979	31.8	5.8	16.7	12.0	66.4
1980	32.9	5.8	16.0	12.1	66.7

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

OECD exports to countries other than the United States, Japan, West Germany, and France were used as a proxy for third country markets. A country's share of this market is its exports to the world, net of exports to the other three countries, divided by the third country market proxy.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

TABLE 21

U.S. SHARES OF WORLD* MERCHANDISE EXPORTS

(Volume Share in 1960 U.S. Dollars)

(In percent)

YEAR	VALUE SHARE	VOLUME SHARE
1960	18.0	18.0
1961	17.5	17.2
1962	17.3	16.9
1963	17.0	17.0
1964	17.3	17.8
1965	16.5	16.2
1966	16.6	16.4
1967	16.4	15.9
1968	16.1	15.3
1969	15.4	14.5
1970	15.2	14.4
1971	13.9	13.3
1972	13.2	13.7
1973	13.6	15.0
1974	12.7	15.1
1975	13.5	15.5
1976	12.7	15.1
1977	11.6	13.9
1978	12.0	14.6
1979	12.0	15.4
1980	11.8	16.3
1981	12.7	16.1

*The World is defined as all IMF member countries.

Source: International Monetary Fund, "International Financial Statistics", various issues.

TABLE 22

U.S. SHARES OF 14 INDUSTRIAL-COUNTRY*
EXPORTS OF HIGH TECHNOLOGY PRODUCT GROUPS

(In percent)

PRODUCT	1965	1970	1980
Aircraft and parts	50.0	60.8	50.5
Office, computing, and accounting machines	35.7	38.1	36.2
Electrical equipment and components	23.8	22.1	17.1
Optical and medical instruments	20.0	17.9	15.1
Drugs and medicines	23.1	16.7	16.1
Plastic and synthetic materials	20.0	12.5	13.9
Engines and turbines	31.3	28.1	28.3
Agricultural chemicals	16.7	20.0	30.3
Professional and scientific instruments	35.7	33.3	30.6
Industrial Chemicals	24.4	22.7	17.6

* The 14 industrial-country group includes: Austria, Belgium-Luxemborg, Canada, Denmark, France, West Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, United Kingdom, and United States

Source: UN Series D Trade Data

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TABLE 23

INDICES OF REVEALED COMPARATIVE ADVANTAGE FOR THE
UNITED STATES, JAPAN, WEST GERMANY AND FRANCE, 1965 AND 1980

PRODUCT GROUP	UNITED STATES		JAPAN		WEST GERMANY		FRANCE	
	1965	1980	1965	1980	1965	1980	1965	1980
1. Aircraft and parts	2.28	2.73	0.05	0.03	0.23	0.61	0.72	0.66
2. Office, computing; and accounting machines	1.47	1.96	0.24	0.89	1.23	0.82	1.25	0.82
3. Electrical equipment and components	1.05	0.92	1.13	2.32	1.13	1.03	0.91	0.92
4. Optical and medical instruments	0.82	0.82	1.58	2.37	1.29	0.92	0.70	0.68
5. Drugs and medicines	0.88	0.88	0.36	0.21	1.17	1.10	1.28	1.26
6. Plastic and synthetic materials	0.91	0.75	1.16	0.69	1.31	1.43	0.94	1.02
7. Engines and turbines	1.35	1.53	0.44	1.04	1.19	1.09	0.57	0.88
8. Agricultural Chemicals	0.72	1.66	1.11	0.38	1.28	0.78	0.98	0.67
9. Professional and scientific instruments	1.48	1.67	0.53	0.58	1.26	1.11	0.60	0.91
10. Industrial Chemicals	1.09	0.95	0.88	0.62	1.38	1.28	1.08	1.23
11. Radio and Television receiving equipment	0.31	0.34	6.37	5.01	1.27	0.99	0.27	0.15
12. Road motor vehicles	0.97	0.67	0.67	2.17	1.80	1.37	0.97	1.11
13. Other chemicals	1.09	1.23	0.25	0.31	1.18	1.19	1.62	1.45
14. Electrical machinery	0.84	0.88	1.06	1.38	1.51	1.27	0.82	1.97
15. Other transportation equipment	1.14	1.01	0.96	1.87	1.44	1.22	0.92	1.04
16. Textile fibers, yarns, and fabrics	0.63	0.93	2.27	1.18	0.70	0.99	1.36	1.01
17. Non-electrical machinery	1.19	1.08	0.55	0.96	1.59	1.39	0.68	0.83
18. Non-ferrous metals, misc. metal products	0.63	0.63	0.98	0.72	0.99	0.94	0.83	0.92

Continued on the next page

TABLE 23
(Continued)

INDICES OF REVEALED COMPARATIVE ADVANTAGE FOR THE
UNITED STATES, JAPAN, WEST GERMANY AND FRANCE, 1965 AND 1980

PRODUCT GROUP	UNITED STATES		JAPAN		WEST GERMANY		FRANCE	
	1965	1980	1965	1980	1965	1980	1965	1980
19. Misc. manufactured products	0.77	0.81	1.56	0.62	1.16	1.12	1.11	0.96
20. Fuels	1.00	0.53	0.10	0.06	1.16	0.53	0.92	0.98
21. Apparel, footwear, and accessories	0.32	0.32	2.09	0.23	0.68	0.86	1.52	1.32
22. Iron and Steel	0.36	0.28	2.35	2.32	1.22	1.17	1.48	1.28
23. Foods, beverages, and tobacco	1.42	1.54	0.34	0.13	0.21	0.52	1.35	1.68
24. Leather and rubber products	0.72	0.48	1.23	1.26	1.00	1.11	1.93	1.76
25. Animal and vegatable oils and fats	2.53	2.06	0.49	0.20	0.49	0.98	0.42	0.83
26. Wood and paper products	0.68	1.06	0.47	0.22	0.28	0.55	0.54	0.64

Source: UN Series D Trade Data

Note: The index is a ratio of a country's world* market share in the product group to the country's total market share.

* The world is defined as the 14 industrial countries.

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Table 24

IMPORTS OF HIGH TECHNOLOGY PRODUCTS
RELATIVE TO HIGH TECHNOLOGY EXPORTS

(In percent)

YEAR	UNITED STATES	JAPAN	WEST GERMANY	FRANCE
1962	22.2	88.7	38.0	73.9
1963	23.5	89.8	36.1	80.8
1964	26.7	81.3	38.5	85.4
1965	29.2	52.8	44.6	79.4
1966	37.3	46.7	41.6	83.5
1967	34.2	52.4	40.9	87.2
1968	35.9	47.2	43.2	94.9
1969	38.0	44.7	47.0	98.9
1970	40.5	51.6	51.6	101.4
1971	44.0	44.7	53.6	100.7
1972	52.5	40.2	51.8	103.9
1973	49.9	44.6	49.0	102.8
1974	44.1	44.7	46.2	102.4
1975	41.0	37.4	53.1	89.4
1976	49.6	34.1	55.0	92.7
1977	53.7	30.3	57.0	90.2
1978	58.3	29.5	59.8	88.8
1979	53.5	35.8	63.9	87.6
1980	51.8	34.5	66.2	97.6

NOTE: The ratios are calculated as the country's imports of the products divided by its exports of the products. The ratios are, then, imports as a percentage of exports.

The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 25

HIGH TECHNOLOGY EXPORT SURPLUS SHARES OF HIGH TECHNOLOGY EXPORTS

(In percent)

YEAR	UNITED STATES	JAPAN	WEST GERMANY	FRANCE
1962	77.8	11.3	62.0	26.1
1963	76.5	10.2	63.9	19.2
1964	73.3	18.7	61.5	14.6
1965	70.8	47.2	55.4	20.6
1966	62.7	53.3	58.4	16.5
1967	65.8	47.6	59.1	12.8
1968	64.1	52.8	56.8	5.1
1969	62.0	55.3	53.0	1.1
1970	59.5	48.4	48.4	-1.4
1971	56.0	55.3	46.4	-0.7
1972	47.5	59.8	48.2	-3.9
1973	50.1	55.4	51.0	-2.8
1974	55.9	55.3	53.8	-2.4
1975	59.0	62.6	46.9	10.6
1976	50.4	65.9	45.0	7.3
1977	46.3	69.7	43.0	9.8
1978	41.7	70.5	40.2	11.2
1979	46.5	64.2	36.1	12.4
1980	48.2	65.5	33.8	2.4

NOTE: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

The export surplus shares are the country's trade balance (exports - imports) divided by its exports.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 26

HIGH TECHNOLOGY SHARE OF U.S. MANUFACTURES SHIPMENTS AND EXPORTS, EXPORT SURPLUS SHARE OF EXPORTS, AND IMPORT SHARE OF APPARENT CONSUMPTION, THE DOC3 DEFINITION[1]

(In percent)

High-Technology Manufactures

Year	Share of Total Manufactures			Export Surplus Share of Exports	Import Share of Apparent Consumption*
	Shipments	Exports	Imports		
1974	13.2	29.3	13.0	55.8	8.3
1975	12.5	28.3	14.0	59.6	8.0
1976	12.5	28.9	16.2	49.8	9.5
1977	12.4	29.3	15.8	45.7	9.5
1978	12.8	30.3	16.5	42.0	10.9
1979	13.3	30.0	16.3	47.7	10.5
1980	14.2	31.5	17.5	50.3	11.2
1981	13.9	32.2	18.8	45.0	11.9

[1] See Table 8.

* High technology manufactures shipments, less exports, plus imports.

SOURCE: Davis, L.A. "Technology Intensity of U.S. Output and Trade," Office of Trade and Investment Analysis, U.S. Department of Commerce, February 1982.

Table 27

DECLINE IN THE WORLDWIDE POSITION OF THE LARGEST U.S. COMPANIES IN TEN INDUSTRIES, FROM 1959 TO 1978

Industry	Number of the World's Largest Companies in 10 Industries	Number of U.S. Companies		Sales of U.S. Companies as % of Sales of All Companies	
		1959	1978	1959	1978
All Ten Industries[2] [3]	117	84	60	78.5	51.0
- High Technology Industries[1]	46	34	25	78.8	47.4
-- Pharmaceuticals[2]	12	9	7	61.6	35.0
-- Chemicals[2]	12	7	4	66.3	31.9
-- Electronic Appliances	14	8	6	75.6	46.9
-- Aerospace	11	10	9	95.4	90.1
- Others	71	50	35	78.3	53.2
-- General Machinery	12	7	6	61.7	51.8
-- Automotive	11	5	3	84.3	59.7
-- Metal Products	11	7	5	66.8	43.2
-- Metal Manufacturing	13	11	4	89.9	32.4
-- Paper and Paper Products	10	9	7	92.2	70.6
-- Food Products	14	11	10	66.6	55.7

[1] The high technology category comprises here slightly different industries from those included in our high technology category in Tables 1-6. We consider chemicals other than pharmaceuticals technology-intensive rather than high technology.

[2] Two German companies, Hoechst and Bayer, which are among the top producers in the chemical and pharmaceutical industries, are counted only once in the totals.

SOURCE: National Planning Association, New International Realities, Volume V, Number 1, July 1980.

Table 28

GROWTH OF R&D EXPENDITURES IN 1975 PRICES FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE: 1964-70, 1970-79

(Percentage Change)

	1964-1970	1970-1979
United States	10	15
Japan	129	81
Germany	90	44
France	41	32

SOURCE: OECD, Science and Technology Indicators Unit

Table 29

R&D EXPENDITURES AS A SHARE OF GROSS DOMESTIC PRODUCT FOR THE UNITED STATES, JAPAN, WEST GERMANY, AND FRANCE: 1964-79, SELECTED YEARS

(In percent)

	1964	1970	1975	1979
United States	3.1	2.8	2.4	2.4
Japan	1.5	1.8	1.9	2.0
Germany	1.4	2.1	2.2	2.3
France	1.8	1.9	1.8	1.8

SOURCE: OECD, Science and Technology Indicators Unit

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Table 30

SHARE OF BASIC RESEARCH IN TOTAL R&D SPENDING FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE: 1964 AND 1977

(In percent)

	1967	1977
United States	13	13
Japan	10	16
Germany	13	20
France	18	21

SOURCE: OECD, Science and Technology Indicators Unit

Table 31

GROWTH OF BUSINESS R&D FUNDING IN 1975 PRICES FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE 1964-70, 1971-78

(Percent change)

	1964-1970	1971-1978
United States	42	31
Japan	-	48
Germany	89	21
France	59	36*

*For France, the estimate covers the period 1970-1977 since data were not available for 1978.

SOURCE: OECD, Science and Technology Indicators Unit

Table 32

GROWTH OF R&D PERFORMANCE OF SELECTED INDUSTRIES IN 1975 PRICES, FOR THE UNITED STATES, JAPAN, WEST GERMANY, FRANCE: 1967-77

(In percent)

	United States	Japan	West Germany	France
Electronic Equipment Components	-	54	-	125
Aircraft	-28	-	170	-16
Motor Vehicles	-	212	79	120
Ferrous Metals	0	153	-60	21
Non-ferrous Metals	60	34	9	65
Instruments	73	272	83	-70
Machinery	66	175	62	-24

SOURCE: OECD, Science and Technology Indicators Unit

Table 33

CHANGE IN GOVERNMENT R&D EXPENDITURES IN 1975 PRICES FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE: 1964-70, 1970-78

(In percent)

	1964-1970	1970-1978
United States	-6	-3
Japan	98	66
Germany	76	30
France	32	6*

*For France the estimate is for the period 1970-1977.

SOURCE: OECD, Science and Technology Indicators Unit

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Table 34

COMPARATIVE LEVELS OF INDUSTRIAL R&D EFFORT[1]
SELECTED YEARS, 1964-79

Country	1964 R&D Millions of U.S. Dollars	1964 R&D % of U.S. Total	1971 R&D Millions of U.S. Dollars	1971 R&D % of U.S. Total	1979 R&D Millions of U.S. Dollars	1979 R&D % of U.S. Total
United States	13,512	100.0	18,320	100.0	37,958	100.0
Japan	573	4.2	4,182	22.8	9,518	25.1
West Germany	972	7.2	3,247	17.7	7,535	19.9
France	925	6.8	2,084	11.4	4,664	12.3
Sum of the Three Foreign Countries	2,479	18.3	9,513	51.9	21,717	57.3

[1] "Industrial" R&D is equated with R&D performed in business enterprises, whatever the source of funds.

SOURCES: Data on R&D in respective countries' currencies obtained from OECD, Directorate for Science, Technology and Industry (Science and Technology Indicators, 1963-1979, January 1982) converted into U.S. dollars by means of purchasing power parities at GDP level. The estimates of these parities are consistent with the benchmark estimates provided by Irving B. Kravis, et al, in A System of International Comparisons of Gross Product and Purchasing Power, Phase I, The John Hopkins University Press, 1975, Idem, Phase II, 1978, and the relative changes in GDP deflators and exchanges over time.

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Table 35

TRENDS IN NUMBERS OF SCIENTISTS AND ENGINEERS
EMPLOYED IN R&D, 1970-1979

	1970		1979		
Countries	(thousands)	As % of total for 4 countries	(thousands)	As % of total for 4 countries	Percent Change 1970-1979
United States	546.5	63.6%	628.6	57.3	18.0%
Japan	172.0	20.0%	273.1[1]	24.9%	58.8%[2]
West Germany	82.5	9.6%	122.0	11.1%	47.9%
France	58.5	6.8%	73.0	6.7%	24.8%
Total-Four Countries	859.5	100.0 %	1096.7	100.0%	27.6%

[1] 1978.
[2] 1970-1978.

SOURCES: "Science and Engineering Employment" 1970-1980, Special Report, NSF, 1981
"Science Indicators", NSF, 1981.
"International Statistical Year", several years, OECD.

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APPENDIX C

SUMMARY OF THE CHANGING COMPETITIVE SITUATION IN SELECTED HIGH TECHNOLOGY SECTORS

AIRCRAFT, THE JET TRANSPORT INDUSTRY

The U.S. civil aircraft industry has traditionally dominated world markets, as late as the mid-1970s, U.S. manufacturers held 95 percent of the world's orders for airliners. Foreign competition has intensified since 1975, however, and by 1981 the European Airbus had captured 26 percent of the jet aircraft market. The decline in U.S. dominance is primarily due to substantially increased development efforts by foreign governments and a simultaneous decline in U.S. government R&D support. The major competitive challenge currently comes from the European consortium Airbus Industries. But, the Japanese industry is rapidly gaining expertise in engines and parts.

ROLE OF RESEARCH AND DEVELOPMENT

The historical U.S. dominance of the jet transport market has been, to a large extent, the result of technological leadership. The expansion of foreign R&D capabilities, much of it government funded, has challenged U.S. technological leadership.

The relative level of U.S. aerospace R&D funding has steadily declined, while foreign nations have increased their R&D expenditures. Although industry-funded R&D has increased, it accounts for only one-fourth of total aerospace R&D expenditures and could not compensate for the decline in federal funding. The average annual level of U.S. government-sponsored R&D was 32 percent lower in the 1970s than in the 1960s. The decline continued in 1980 when total U.S. expenditures fell 13 percent from their 1979 levels.

INCREASING COMPETITIVE CHALLENGE

In 1979 the Airbus was second to Boeing in sales and had as many orders as McDonnell Douglas and Lockheed combined. The consortium is composed of Aerospatiale of France, Deutsch Airbus (MBB and VFW-Fokker) of Germany, British Aerospace and CASA of Spain. With the exception of Fokker, all of the companies are fully or partially government owned.

Both the German and French governments have heavily funded the Airbus program. The Germans estimate they will have to invest over $1.1 billion through 1985. The French government had invested one billion dollars through 1980, and has budgeted $1.2 billion in additional funding through 1985. The Chairman of Fokker summed up the Airbus dependence on government funding in the July 1979 issue of Interavia magazine: "It's a delicate subject - Airbus. It's a successful aircraft, but it requires basic support from the German and French governments. As you have written yourself 10 million Deutsche marks ($4.2 million) per aircraft."

The U.S. industry faces strong competition for the jet transport market of the 1980s. To meet the expected demand of the next decade, U.S. companies are offering a mixture of new designs and advanced versions of existing designs that incorporate the most advanced technology. Europe's Airbus will launch two new models which, in light of recent Airbus successes, must be expected to be highly competitive. Moreover, as the highest growth markets are predicted to be outside the United States, this could prove to be an asset for foreign manufacturers.

An additional challenge can be expected from Japan in the future, though largely in parts and engines. The Japanese are currently involved in numerous joint development and production programs with major U.S. and European manufacturers. Involvement in these programs has enabled the Japanese to acquire the state-of-the-art expertise necessary to increase their role in the market in the 1980s.

ADDITIONAL REFERENCES: Bureau of Industrial Economics. 1982 U.S. Industrial Outlook. U.S. Department of Commerce, 1982.

Civil Aviation Advisory Group Aerospace Technical Advisory Council. "The Challenge of Foreign Competition to the U.S. Jet Transport Manufacturing Industry," Aerospace Industries Association of America, The Aerospace Research Center, Washington, D.C., December 1981.

SPACE

Space commercialization is a matter of economic necessity. Yet the United States' lead in space is slipping. The U.S.S.R. launches many more vehicles each year than the United States. France, in cooperation with its European neighbors, is rapidly developing a launch capability that directly challenges the United States monopoly in launching communication satellites, the only current area of space activity that is commercially self-sustaining. Most of the satellites themselves are still made by U.S. companies, in part because of the tie-in with U.S. launch vehicles.

Space launch activity in the United States has been and is the province of the U.S. government. Civil launches are handled by the National Aeronautics and Space Administration (NASA), and military launches are the responsibility of the Air Force. Although the only U.S. manned space activity in the near future will be the use of crews on the Space Shuttle, planning has begun for the establishment of a permanent manned presence in space.

COMSAT was created by statute to move the commercialization of space communications into the private sector. COMSAT is a member of INTELSAT, the international communications satellite consortium. Commercialization has been largely successful, with the launch of those satellites dependent on NASA. Indeed, NASA has handled almost all civil space launches outside of the Soviet bloc countries. This near-monopoly of service is ending. INTELSAT has already scheduled satellites for launch on Europe's Ariane vehicle in the mid-1980's, as have two U.S. firms.

The European Space Agency (ESA) was created as the European answer to NASA. As of the end of 1980, only one European-launched spacecraft had attained earth orbit or beyond, while 756 U.S.-launched spacecraft attained earth orbit. The number of U.S. launches has fallen steadily -- from 26 in 1976 to 13 in 1980. Japan, on the other hand, has launched at the increasing rate of 1, 2, and 3 per year; and Europe, with its Ariane launch vehicle, is also increasing its commercial as well as military launches each year.

The Space Shuttle will carry national security payloads that may claim priority on the basis of national security requirements. Normally, payload launch dates are negotiated on a first-come, first-served basis.

The estimated requirements for space launch services by the mid-1980s will exceed the capacity of the available shuttles by a factor of two. An understanding of this problem has surfaced outside the United States, and the French have gone on a marketing campaign to secure the overflow traffic for Ariane launches.

At a time of increasing space commercialization, the United States stands in an uncomfortable competitive position, attributable to:

- o phasing down U.S. dependence on expendable launch services;
- o a potentially inadequate capacity to meet future demand for space launch services, whether military or civil in nature; if expendable launch vehicles are phased out and no additions are made to the Shuttle fleet;
- o high-priced expendable launch services because of the full cost recovery policy and because improvements to expendable launch vehicles have slowed. The latter is the result of the assumption that all launch services would be handled by the Shuttle at reduced launch costs per satellite;
- o French Government economic policies and subsidies, which result in prices for Ariane expendable launch services being roughly 20-25 percent below the prices quoted by NASA for commercial expendable launch vehicles and services, but above quoted Shuttle prices;
- o Arianespace, an independent quasi-commercial organization, can offer financing terms more favorable to the customer than those presently available through NASA;
- o the French plan for rapid evolution of the Ariane launch vehicle to meet future needs of the commercial satellite industry;
- o the Japanese pattern of putting up satellites, quietly, with little fanfare, aided in part by the transfer of Delta launch vehicle technology. In time, they could assume a launch support role for commercial satellites, but our agreement with Japan includes prohibitions on their competitive activities for launch services suppliable by U.S. system.

ECONOMIC IMPLICATIONS

Pricing of U.S. launches is artificial, set by Government policy rather than as the result of private negotiation between launch customer and commercial launch vechile supplier. U.S. companies will secure the services needed for commercial launches on the basis of price, lift capability, and launch date.

U.S. Shuttle launches will be used first by the military and other U.S. Government agencies. As for commercial payloads, there is some concern about schedule preemption by military payloads (for national security) and, as the French develop a reputation for the launch services, more satellite owners, U.S. and foreign, will begin to buy such services overseas. This has serious potential implications for the multi-billion dollar satellite construction business, now dominated by U.S. companies.

U.S. Government policy and budget constraints have limited the speed of commercialization of space, in part because of pressures on the NASA budget. Commercial launch vehicle services are available only through NASA and the enormous cost and technical risk of space commercialization has deterred investment by the private sector in other areas, except in cooperation with government. Although several ventures to provide launch services commercially have been proposed -- both for operation of the Shuttle and for expendable launch vehicles -- it is unlikely that the private sector could enter the commercial market in competition with NASA.

ROLE OF NATIONAL GOVERNMENTS

In France, the government assumes the responsibility for basic research and some application development. When the point of commercialization arrives, the technology is turned over to the quasi-public companies for marketing, distribution and overall commercialization. Arianespace has stockholders from several governments in Europe, plus private individuals, private firms, and private banks.

In the United States, launch vehicle services (except for upper stages) are totally handled by the Government, using the manufacturers as prime or subcontractors to provide the mechanical services needed for specific launches. Although production and sales of communication satellites are totally commercialized, the companies have little, if any, role in either developing evolutionary/revolutionary launch vehicles or in pricing vehicles and services, except for upper stages. Other areas of space commercialization remain to be explored.

ADDITIONAL REFERENCE: Office of Technology Assessment, Civilian Space Policy and Applications, Congress of the United States, 1982.

COMPUTERS AND SOFTWARE

The United States retains broad leadership in computer hardware and software production and technology. The high growth areas in the computer industry today are personal computers, office automation, software, and services..

HARDWARE

While mainframe production is dominated by relatively few large companies, many smaller companies have entered the smaller, personal computer market. Many of the larger companies are also giving added emphasis to the micro- and minicomputer market, where growth rates are well above those in the mainframe sector.

The major foreign competitor in computer hardware is Japan, whose companies have products competitive with a range of U.S. equipment, including large scale general purpose processors, magnetic disk storage and printers. In the large scale systems sector, Japanese firms have produced equipment equalling or exceeding U.S. capabilities, relying on their growing strength in high speed logic, and memory components.

Japan has targeted the large scale scientific processing sector, the so-called supercomputers, where U.S. firms have been unchallenged leaders. The leading Japanese computer firm recently announced a supercomputer which it claims rivals the performance of current U.S equipment. The Japanese began a 10-year joint government-industry effort to produce a "5th generation" computer system, by which they hope to leapfrog U.S. leadership in computer technology.

SOFTWARE

Despite impressive growth in sales over the past few years, software productivity has not kept up with the expanded use of computers, especially microprocessor-based systems. Software now accounts for a growing percentage of a typical computer's cost, while hardware's share, which used to account for the bulk of a system's cost, is steadily declining.

A shortage of workers with key skills has been an important contributor to the rising cost of software. A 1981 study reported 54,000 job openings for graduates with degrees in computer science but only 13,000 graduates with the necessary skills to fill those positions.

There have been significant changes in the software sector, which may help ease the software bottleneck. For example, in the microcomputer sector, there are now several standard operating systems and high-level programming languages that a growing number of suppliers are implementing on their equipment. Software producers are also able to increase their efficiency by using a range of programming and automated software development. The Japanese, who traditionally have lagged behind the U.S. industry in software, have increased their research in this sector, aided by government funding.

ADDITIONAL REFERENCES: Bureau of Industrial Economics, 1982 U.S. Industrial Outlook, U.S. Department of Commerce, 1982.

Science. Vol. 215, February 12, 1982, American Association for the Advancement of Science, Washington, D.C. This issue is devoted to computers and electronics.

SEMICONDUCTORS

OVERVIEW

Semiconductors, devices which modify electrical signals, are essential in industrial electronic equipment (37% of 1979 sales that amounted to $10.5 billion), computers (30%), consumer electronics (22.5%), and military systems (10%). The motivating power of the industry's growth is in integrated circuitry: without technological growth in integrated circuitry, there would be little growth elsewhere. Integrated circuits are produced principally in the U.S., Britain, France, West Germany, and Japan.

The industry's firms in the U.S. are comprised of merchant firms that produce advanced integrated circuits and customized integrated circuits, and IBM and ATT which produce semiconductors only for their own consumption. The concentration of U.S. industry has not changed substantially: twenty firms have accounted for about 80% of sales in the last couple of decades (there has been a large turnover in the twenty). In Europe and Japan, the great share of semiconductor production is by mutliproduct firms similar to General Electric.

In Japan, six firms accounted for 79% of sales in 1979, and in Europe, the industrial concentration appears similar. Both Japanese and European firms have acquired part ownership of U.S. firms to facilitate market entry and technology transfer. Most of the technology growth in the industry has occurred in integrated circuitry and has had major impacts upon equipment in the four sales markets.

Major product innovations have been and continue to be the increasing density of the circuits (VLSI), the metal oxide semiconductors having favorable electrical properties, and increasingly efficient production techniques.

Moore's Law, valid since the mid 1960's, says that integrated circuit function density doubles every year with an associated decrease in cost of about 30%. For each chip density there is a similar "learning curve" showing the rapid rate at which lowest practicable unit cost is achieved. Given Moore's Law and the learning curves, it may be possible for a set of colluding firms to practice predatory pricing to exclude other firms once they have gained market dominance.

The United States' share of world shipments of integrated circuits held nearly constant in all markets in the period 1978 to 1981. A world production of integrated circuits was over $14 billion, a doubling since 1978. In this latter period, the Japanese share of market had somewhat declined from 18% to 15%.

A major threat has been posed by Japan's capture of 40% of the 16K random access memory (RAM) market, early introduction of the 64K RAM, and strong positions established for the 256K RAM in the metal oxide semiconductor markets. While European countries appear to recognize the importance of the semiconductor technology with governmental support, their industries are not yet a threat except in the specialized complementary metal oxide market.

The competitive threat in the current period is from Japan. The threat posed is mainly to U.S. merchant firms that sell on the open market and have been major contributors to technology growth. Some analysts contend that the major Japanese firms have rationalized their industry by allocating home markets in electronic devices and inhibiting both local and foreign new entry. It is claimed that these firms, using venture capital from these large scale market sales, and using recent substantial government augmenting research funds and expertise, have made it possible to target individual U.S. and world markets.

A major concern is that cooperating Japanese firms would dominate many U.S. electronic markets. They will then be able to practice a pricing policy that will limit U.S. merchant firms in the world markets just as U.S. industry appears to be limited in Japan. Large scale U.S. firms have made major contributions to the semiconductor market, but technology growth would have been much slower without the contribution of the open market firms. Thus the slowing of advances on the part of the smaller merchant firms as a result of foreign competition is highly significant.

Nonetheless, the U.S. merchant firms are not stagnating and appear determined not to allow a repeat of the 16K RAM market loss. An indication of this is seen in recent expenditures on semiconductor plant and equipment. The ten largest Japanese firms have spent $500 million in 1980 and $775 million in 1981 (about 18% of sales). The ten largest U.S. merchant firms have spent correspondingly, $910 million in 1979 and 1.2 billion in 1980.

FIBER OPTICS

Fiber optic technology has advanced rapidly since the late 1960s and now offers an ever increasing number of applications. Fiber optics have several advantages over conventional wire: they are capable of carrying much more data than wire of comparable size, they are light weight, non-conductive, neither create nor are affected by electromagnetic fields, and cannot be tapped without the risk of immediate detection. Some of the applications of fiber optics include high-density telephone transmission, computer and data transmission, office automation systems, and home video systems (cable television, videophone, and closed-circuit television).

FIBER OPTICS SYSTEMS

In a fiber optics system, pulses of light are transmitted through hair-thin optical glass fibers. There are three components of the system: light source, transmission medium, and detectors. The light source is usually a solid state laser (typically made of aluminum-gallium-arsenide) or a high-radiance light-emitting diode. Detectors are either silicon pin diodes or avalanche photodiodes. The transmission medium is generally glass but plastic-core cables have been developed for short-distance applications. The costs of fiber optics systems will decrease as these components become standardized. For example, in 1980, three U.S. companies developed standardized components for a fiber optics system suitable for short-distance, medium-speed applications. The package of components cuts the cost of relatively low-performance fiber optics to that of conventional conductors.

COMPETITION

The Japanese have been cited with a lead in light source technology and application and are competitive with the United States in the other component technologies. In Japan, MITI has targeted optoelectronics for rapid development. The Engineering Research Association in Optoelectronics Applied Systems is the core body for managing government-subsidized projects in fiber optic and other optoelectronic R&D projects. These include an $80 million optical instrumentation and control system project funded by MITI.

The falling prices of fibers and other components will permit more extensive application of this new technology in the coming years. Shipments of fiber optics systems and equipment exceeded $60 million in 1979. Increased economies of scale made possible by improvements in technology and production methods, and the higher degree of standardization being applied suggest shipments of fiber optic systems and equipment should exceed $500 million by 1986.

BIOTECHNOLOGY

The global research, industrial, economic, social and political interest in biotechnology has expanded exponentially since the mid-1970s. With the possible exception of the United States, most industrial nations have developed industrial policies or national plans that explicitly encourage investment and research in biotechnology. Major areas for application of biotechnologies identified in national reports include: pharmaceuticals/health, chemicals, energy, food processing, and agriculture.

In addition to national governments' interest in biotechnology, industy's emphasis in the future on conserving energy, on improving process efficiency, on reducing industrial hazards, and, where applicable, on moving to production of higher value added products will favor increased use of biotechnologies.

Use of fermentation and other key biotechnology process tools (enzymes, plant and animal cell cultures, recombinant DNA) will become industrial technologies of choice for the production of commercial products in the long-term. With the exception of fermentation technologies, the United States probably has the technological leadership in such biotechnological areas as recombinant DNA and cell culture technologies. These technologies, however, will only serve as tools in future commercial industrial processes. Thus, biotechnological process engineering leadership will be the critical determinant for the long-range competitiveness of those industries dependent on this technology. There are gaps not only in our technological leadership in this area but also in the manpower available to meet future industrial development needs.

Few of the factors that have affected the international competitive position of the United States in other high technology industries have had an impact on the budding biotechnology industry. Since no one is yet producing commercial products, such factors as comparative production costs and foreign pricing practices are not an issue. Capital availability does not seem to be a constraint. Large amounts of venture capital have been supplied to many small biotechnology firms in the United States to support research and product development and testing, even though most of these firms have yet to realize any sales revenue. However, capital requirements are expected to increase rapidly as firms progress to product development and commercialization, a factor favoring the major drug firms involved in the industry.

Other industrialized nations are willing to invest in filling the technological leadership voids in biotechnology. The initial cost of biotechnology research operations are not great and firms in many countries have become involved.

Japan has leading edge and extensive industrial experience in fermentation technology. MITI's vision of the 1980s report declared a strategy to deemphasize energy intensive industries and emphasive high technologies, such as biotechnology. Japan has taken a number of steps to implement their long-range government-industry strategy in biotechnology including: (1) establishing a chemical industry consortium in biotechnology, (2) formimg a fourteen-company biotechnology research organization, and (3) ensuring Japanese firms' active interest and investment in and establishment of cooperative technology transfer agreements with U.S. biotechnology firms.

There is already considerable interest in the industrial potential for biotechnology in Europe. West German industrial firms began to make substantial investments in this area in the early 1970s and West Germany is presently the technological leader within the European industrial community. Competition will increase for West Germany in biotechnology, however, as traditional European industries suffer economic difficulties over the next decade and transitions are made to high value added industrial products. European firms have been slower to invest in U.S. biotechnology companies. However, Elf Acquitaine has recently invested in Engenics, a biotechnology process engineering R&D firm.

PHARMACEUTICAL INDUSTRY

The pharmaceutical industry is one of the most successful high technology sectors of the world economy. The demand for pharmaceuticals is large and growing. The flow of new products has been sustained at a high level for 40 years, and the individual companies are generally financially healthy.

American firms dominated world pharmaceutical markets between 1940 and 1960, accounting for the vast majority of research efforts and new products, produced over half of world pharmaceutical, and controlled one-third of international trade in medicinals.

Since the early 1960s, the U.S. share of world pharmaceutical research, innovation, production, sales, and exports have declined. Additionally, the number of U.S. firms that are active participants in the various ethical drug markets have been constant or declined relative to their foreign counterparts since 1960.

DECLINE IN INNOVATION

Patented drugs represent the driving force of the modern pharmaceutical industry and are responsible for the spectacular growth in sales since 1940. Modern pharmaceutical firms depend on a small handful of successful innovations for the bulk of their positive cash flow. Competitive advantage in sales of patented drugs, by far the most lucrative segment of the industry, depends on the ability of the firm to produce a slow but steady stream of commercially successful new products through industrial innovation.

The process of pharmaceutical innovation is characterized by substantial risks. This is, in part, a result of the lengthy time frame--sometimes approaching fifteen years--from initiation of basic research to the commercial launching of a new product. While U.S.-owned firms' expenditures for pharmaceutical research at home and abroad are large and growing, they have not increased to the extent where they can match the exceptional expansion of foreign-owned research efforts. The share of world pharmaceutical research located in the United States remains the largest, but has fallen from about two-thirds in the early 1960s to above one-third today. Research expenditures have grown faster throughout the period in Japan, West Germany, and the United Kingdom.

Levels of innovation in the industry have been, at best, stable for the last two decades but have sharply dropped from the levels of the 1950s. The average cost per innovation has risen drastically in the last 20 years. A frequently cited figure is $54 million (1976 dollars) per new chemical entity (NCE). The fundamental reason for the dramatic increase in innovation costs lies in the substantially greater number of clinical trials and toxicology testing performed in the process of bringing a new compound to market. The upward trend in costs is an international phenomenon that has led all industrial nations to comparable extensive pretesting and selectivity in pursuit of new drugs. The inevitable consequence has been a worldwide decline in introduction rates. Yet, foreign levels of innovation have declined less severely since the 1950s than U.S. levels

Two basic changes in the structure of the world pharmaceutical industry have evolved during the past two decades: greater concentration of innovation among larger firms and increased internationalization of the industry. The higher costs per innovation for smaller firms render small-scale research operations relatively less productive per dollar spent and, hence, less profitable. A consequence of this development has been the declining significance of smaller firms in the pharmaceutical innovation process.

Between 1965 and 1975, U.S.-located production grew 5 percent annually compared to 15 percent rate abroad. Growth rates of overseas production for U.S.-owned firms exceeded those of domestic producton, with foreign production accounting for 40 percent of the U.S. multinational total in 1978.

Pharmaceutical products have traditionally provided a surplus for the U.S. trade balance. Yet, this surplus in absolute terms is not significantly greater than those of Switzerland, West Germany, or the United Kingdom, who export a larger percentage of their production than the United States despite the substantially larger level of U.S. production. This lower level of exports as a proportion of domestic production provides the United States with a comparable share of world pharmaceutical exports, a share which has markedly deteriorated since 1950. In part, the low proportion of pharmaceutical preparations production devoted to exports is associated with the relatively more extentive multi-national scope of U.S.-owned firms, which has resulted in significant exports of medicinal chemicals. Equally important is the traditional relative unimportance of exports to U.S. producers, as may be seen by a comparison of total U.S. exports to GNP. From this perspective, the U.S. pharmaceutical industry is typical of other sectors of the American economy.

BARRIERS TO U.S. EXPORTS

While tariffs are of little consequence to U.S. pharmaceutical exports, non-tariff barriers most definitely are. The French have a visa system which, in practice, favors French firms rather than the affiliates of foreign companies. The United Kingdom, through its price regulation, gives firms an incentive to perform R&D there instead of in the United States. But in general, the most important barrier to U.S. exports is FDA regulations preventing the export of any new drug until it has been approved for sale in the United States. This applies even if the product has been formally approved for marketing in the importing nation. With the delays that occur in obtaining FDA approval, U.S. firms have more incentive to manufacture new drugs abroad.

INDUSTRIAL ROBOTICS

Industrial robot manufacturing has experienced rapid growth during the past two years, and industry observers project average annual growth rates of 35 percent or more during the coming decade. The first industrial robot was developed in the United States about 1960, and the United States continues to be the world leader in research and design. But in the past decade Japan has far surpassed the United States in both the production and use of robots.

The U.S. robotics industry has been dominated by two firms -- Unimation and Cincinnati Milacron. Together they accounted for about 70 percent of U.S. robot sales in 1980. With the entrance of several new firms into the industry, however, this share is expected to drop to 50 percent in 1982. The past two years have seen a tremendous upsurge in interest in robots. There has been a dramatic increase in the corporate membership of the Robot Institute of America, the industry trade association, from 45 in 1979 to 172 in 1981. Several U.S. firms (General Electric, Westinghouse, Automatix, and others) have concluded licensing agreements to market robots built by foreign companies--West German, Italian, Swedish, and Japanese. In the case of at least one of these firms, General Electric, licensing is seen as an entrance to the market while work continues on the development of their own robots.

The belated but rapidly growing interest in robots in the United States is due in part to the increasing economic justification for purchasing robots resulting from declining robot prices and rising wage levels in recent years. Reports by industry analysts suggest that existing and potential robot manufacturers are only awaiting assured markets before investing in the additional capacity needed to sustain the surge that is under way.

Capital availability does not seem to be a constraint. More than $30 million in venture capital was channeled into U.S. robot companies during the past two years. After the surge of new producers in the next few years, analysts expect a "shake-out" with the number of bankruptcies and acquisitions increasing. Survival will depend on producers being financially strong enough to develop programmable robots or to carve out specialized niches. Prices for sophisticated robots will also go down as the result of increased competition and economies of scale. By 1990, according to one study, almost half of factory assembly operations will incorporate robot technology, compared with only 5 percent today.

FOREIGN COMPETITORS

The first Japanese robots were produced in the late 1960's under license from American firms. Many of the Japanese producers initially designed and built robots for their own use and only later decided to market them. Domestic demand has continued to absorb most of their output, with exports currently accounting for only about 3 percent. A movement toward increased exports is now under way and the Japanese Industrial Robot Association projects exports of about 15-20 percent of total output during the second half of the 1980s.

Japanese manufacturers have developed robots for a broad spectrum of applications. The development of their robot industry was aided by a much more receptive climate in Japan than in the United States and by direct government efforts to encourage robot use and support robotics research. Factors most frequently mentioned are:

- The management of many Japanese companies turned to robotics during the 1970s as a means of achieving higher quality (greater precision, lower defect rates) and improving productivity.

- Labor in Japan has been receptive to robots because of the permanent employment policy, company efforts to retrain those displaced, and the fact that workers share in the larger profits resulting from higher productivity.

- The major government actions have been:

    a. direct low-interest loans through the Small Business Finance Corporation to small and medium-scale manufacturers for robot purchases;

    b. extra depreciation allowances on robots--an additional 12.5 percent each year for three years (a firm can depreciate 52.5 percent of the purchase price in the first year);

    c. encouraging the formation in 1980 of the Japan Robot Leasing Company (JAROL), which is jointly owned by 24 robot manufacturers and 10 insurance companies (since 60 percent of operating expenses are financed by low cost loans from the Japan Development Bank, JAROL can provide very attractive leasing terms); and

    d. a major new effort to support R&D in robots--$150 million to be allocated by MITI over seven years, beginning within the next year, to push the development of intelligent robots.

West Germany has several important robot manufacturers, and the government provides considerable support for R&D and for the training of engineering and technical personnel. Their production has been primarily for internal consumption and for other European countries. Few of the West German robots have reached the United States.

Italy was one of the earlier starters in robotics, but their production volume is low. The Italian firms Olivetti and DEA have recently signed licensing agreements with U.S. firms to market their robots in the United States.

The major French robot producer is Renault, which also has a licensing agreement with a U.S. firm. The French government is firmly behind automation and robotics programs, and it is estimated that the government is putting about $25 million per year into funding related research programs.

The United Kingdom has gotten off to a slow start in robotics, hampered by union problems, but has set up a Scientific Research Council to focus on this industry.

The U.S.S.R. has an entensive robotics research program, but is at least a decade behind the United States in robotics technology. It is receiving about 100 robots a month from a factory in Bulgaria. Poland has a limited research effort and very little production.

THE OUTLOOK FOR THE 1980s

The wider use of robots encouraged by government policies has given the Japanese the lead not only in the quantity produced but also in the range of applications. At present about 55 percent of all robots in the United States are used in the automotive industry. In Japan, about one-third of all robot shipments have been to the automotive industries, and one-quarter to the electric appliance industry. In the United States about 49 percent of all robots are used for welding and painting, and 21 percent for machine tool loading and assembly operations. In Japan the corresponding shares are 16 percent and 77 percent. The latter two applications are expected to be the major U.S. growth markets in coming years. That the Japanese already have product-development experience in these areas should give them an advantage in the U.S. market.

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MACHINE TOOLS

The machine tool industry in the United States is quite small, yet it is important to U.S. economic and military strength Virtually every major manufactured product is produced on machine tools or on machines built by machine tools. Modern and efficient machine tools are needed to meet increased military production demands in times of national emergencies. Many major American industries, such as the automotive and other transportation industries, are closely dependent on machine tools for the maintenance of their competitiveness in domestic and world markets. Increased foreign penetration of the U.S. market, coupled with a decline in world market share of machine tools, are sources of concern for the future of the U.S. industry, in spite of increasing orders and shipments.

LOSS OF MARKET SHARE

The U.S. machine tool industry employs approximately 100,000 persons and its output is valued at around $4 billion. Two-thirds of the companies are small, employing under 20 persons. The U.S. share of worldwide production of machine tools was around 35 percent in 1967 but dropped precipitously to 17 percent in 1971 where it has since leveled out. Western Europe has maintained a steady share between 15 and 20 percent. Japan's share, on the other hand, has shown a rapid increase from 5 percent to 13 percent. The U.S. industry had a negative trade balance for the first time in 1978--by 1980, the deficit had grown to over $500 million. Imports now account for 24 percent of U.S. consumption. U.S. exports of machine tools in 1980, valued at $743 million, trailed behind West Germany, Japan, Italy, and Switzerland.

The machine tool industry suffers from highly cyclical demands, causing periods of "feast or famine." This was especially evident during the period 1967-1971, when there was a drop in U.S. machine tool consumption of around 48 percent. The industry did not offset this slow period by increasing its exports into an expanding world market. Instead, many companies "retrenched," cutting back on personnel, capital expenditures, and research and development, and discarding marginal product lines. However, this resulted in long lead times, large order backlogs, and therefore, increased vulnerability to foreign competition.

NEW TECHNOLOGIES

Many American tool builders have also failed to keep pace with the productivity, quality, and cost savings of their international competitors. While many of the new advances in product design and manufacturing techniques are developed in the United States, our industry has been less willing to take advantage of them than our competitors. The Japanese study mission of the National Machine Tool Builder's Association toured 13 Japanese factories and found: "Nowhere in the 13 factories toured by our study group did we see any unique manufacturing technology. In general, Japanese machine tool builders use the same types of machinery to build their products as in America. However, the equipment and technology are very intelligently applied and many builders are investing heavily in the latest technology to improve productivity further."

Computer numerically controlled machines (CNC) and flexible manufacturing systems (FMS) will play a major role in the machine tool industry in the coming decade. An FMS consists of a group of CNC tools connected by a mainframe computer. These systems are used to manufacture a family of diverse parts. The emphasis among U.S. companies is still on simple machines, however, rather than systems. The Japanese, on the other hand, have targeted flexible manufacturing systems as a specialty to mass market and their experience will give them an advantage as demand increases in world markets.

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APPENDIX D

THE INNOVATIVE PROCESS

This appendix provides some background on definitions and key considerations concerning innovation. Further background information can be found in the selected sources discussing the innovative process which are listed at the end of the appendix.

Definitions of Research and Development

The National Science Foundation (NSF), in its surveys of industrial technology activities, separates the innovative activities of firms into three categories: Basic Research, Applied Research, and Development. Basic research is generally considered to be long-term in nature, not focused on specific, identifiable short-term objectives. However, basic industrial research is ultimately aimed a producing or improving upon a marketable product. Applied research is more specific and, presumably, short-term. Since basic research and applied research have similar ultimate objectives it is frequently difficult to distinguish between the two in industrial settings.

The NSF definitions of research and development and the three categories of R&D activity are:

"Research and development - Basic and applied research in the sciences and engineering and the design and development of prototypes and processes. This definition excludes quality control, routine product testing, market research, sales promotion, sales service, research in the social sciences or psychology, and other nontechnological activities or technical services."

"Basic research - Original investigations for the advancement of scientific knowledge not having specific commercial objectives, although such investigations may be in fields of present or potential interest to the individual company."

"Applied research - Investigations directed to the discovery of new scientific knowledge having specific commercial objectives with respect to products or processes. This definition differs from that of basic research chiefly in terms of the objectives of the individual company."

"Development - Technical activities of a non-routine nature concerned with translating research findings or other scientific knowledge into products or processes. Does not include routine technical services to customers or other activities excluded from the definition of research and development given above."

Innovation

Industrial innovation is generally defined as the initial commercial application of a new product or process. Innovation encompasses changes in either product features or production processes to reduce costs. For our purposes, innovative behavior can be considered to include both innovation by a firm itself and the adoption and improvement of innovations made by others. The activities leading to innovation involve a long-term process incorporating the various stages of research, development, capital investment, and commercialization.

Factors In the Innovative Process

Innovation by a firm is influenced by both internal elements and conditions outside the firm that provide it with opportunities or constrain its behavior. The government, rather than individual firms, has principal influence over the external elements.

Major External Factors -- Important external factors have been identified to include the following:

- The technological base: The state of overall knowledge in the economy, the flow of scientific and technical manpower to industry and the amount of on-going basic research in government and academic institutions.

- Overall economic conditions: Aggregate demand and investment rates, which tend to promote or restrict innovation, and effect the rate of adjustment--particularly of labor--to technological change.

- Price stability: Rates of inflation and financial market volatility which can particularly affect innovation. (Under high inflation firms show preference for short-term, low-risk investments rather than radical innovations with risky and long-term return characteristics,)

- Industry composition: Industry structure in terms of concentration and size of firms which influence whether firms are large enough or secure enough to carryout innovative changes with long-term returns.

- Government policies: The government policies affecting industries, whether targeted to industries or toward other national objectives. (Government regulations, specifically, can cause a concentration on short-term problem-solving.)

- R&D incentives: The degree to which the external economies, riskiness and indivisibilities in R&D are accounted for. (Studies of the social rate of return to R&D programs indicate that the marginal social rate has been very high versus the private rate -- thus suggesting potential underinvestment in R&D.)

Major Internal Factors -- Firm resources and actions at all levels can have a significant influence on innovation. Important specific elements include:

- Corporate goals: Specific objectives concerning the rate of return, market share, profit growth, etc., which in everyday operation guide decisions about entering into new products or processes.

- Firm organization: Degree of vertical integration and type and amount of capitalization. (The proportion of debt relative to equity, cash flow, and size of working capital all affect the ability to develop new products, new plant and equipment, and compete in markets.)

- The state of internal coordination and communication: Degree to which all levels of the corporation focus on the development and practical application of technology, from project selection, technical discoveries, through marketing success.

- Managerial quality: Level of understanding of technological base of the industry, and technical sophistication of management. (Managers selected primarily for business and general management skills may lack appreciation for the necessity of long-range research and development programs. For instance, U.S. practices of high-level executives moving between industries with insufficient time to learn about the industry's technical base, contrasts with Japan's relatively long executive ties with the same firm and the technical expertise acquired as a result.)

- Company reward systems: Rewards and bonuses based on short-term versus long-term results. (Long-term investments in new and relatively risky technologies have little immediate payoff and will not be encouraged if rewards emphasize short-term results.)

Innovation and Risk

One of the obvious characteristics of the innovative process is its riskiness. This uncertainty can be broken down into three primary categories: (1) the chance that a project will not be technically completed, (2) the chance that a product, if technically completed, will not be commercialized, and (3) the chance that a project, if commercialized, will not be economically successful.

Empirical investigations of the innovative process provide evidence of the risks associated with innovative activities. An early study by Booz, Allen and Hamilton concluded that 7 out of 8 hours devoted by scientists and engineers in major firms to technical product development are spent on unsuccessful projects, and that 5 out of every 10 products that emerge from R&D fail in product and market tests, and only 2 become commercial successes. A detailed study of the R&D portfolio of several chemical and drug firms indicated that, on the average, about 43 percent of the projects that were begun were not technically completed, about 45 percent of those that were technically completed were not commercialized and about 62 percent of those commercialized were not economic successes -- that works out to a success rate of approximately 12 percent of the R&D projects initiated. Though the probability of success varies among industries and among firms within an industry, the high level of risk associated with innovation can easily lead to underinvestment in these activities.

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